

ZOOGOER

NOVEMBER • DECEMBER 1990





**Friends
of the
National**

is a nonprofit organization of individuals, families, and organizations who are interested in helping to maintain the status of the National Zoological Park as one of the world's great zoos, to foster its use for education, research, and recreation, to increase and improve its facilities and collections, and to advance the welfare of its animals.

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Director: Michael H. Robinson.

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Cover: Early stage in the medusa life cycle of jellyfish, *Aurelia ephyrae*. (Photo by Freya Sommer, copyright Monterey Bay Aquarium.)

Annual Report 1990

Over the past 33 years, the National Zoological Park and Friends of the National Zoo have built an impressive and important partnership—a partnership that continually adapts and changes to meet new challenges. For FONZ, 1990 has been a year of assessing and planning for the challenges of the future as well as consolidating and building on past achievements.

In the most significant event of 1990, the Smithsonian Institution and FONZ reached agreement on a new, 10-year contract to manage the food, merchandise, and parking concessions at the Zoo. The new contract ensures FONZ's uninterrupted support for Zoo research, conservation, and education programs through the end of the century. This takes on even greater importance in light of near-certain reductions in federal support for the Zoo as the government faces rising budget deficits. Fortunately, healthy concessions revenues in 1990 augur well for FONZ's ability not only to sustain but to increase its support for these essential programs.

For the same reason, FONZ has increased its development efforts as well as its support for the Zoo's development efforts. FONZ worked to cultivate new and diverse sources of support for the Zoo in the community. These already productive efforts we hope will reap even greater rewards in the future.

A major achievement of 1990 was the overwhelming success of National ZooFari, which has steadily grown over the last seven years in both popularity and proceeds. The \$105,000 that ZooFari 1990 raised represented a 25-percent increase over 1989, and a more than 100-percent increase over 1988.

The success of ZooFari, like that of so many Zoo and FONZ programs, depends on the enormous contributions of FONZ volunteers who, in 1990 alone, numbered more than 750 people working some 67,000 hours at the Zoo. The tree sculpture, *Volunteers*, dedicated at the 1990 Annual Meeting, is a marvelous tribute to these selfless individuals.

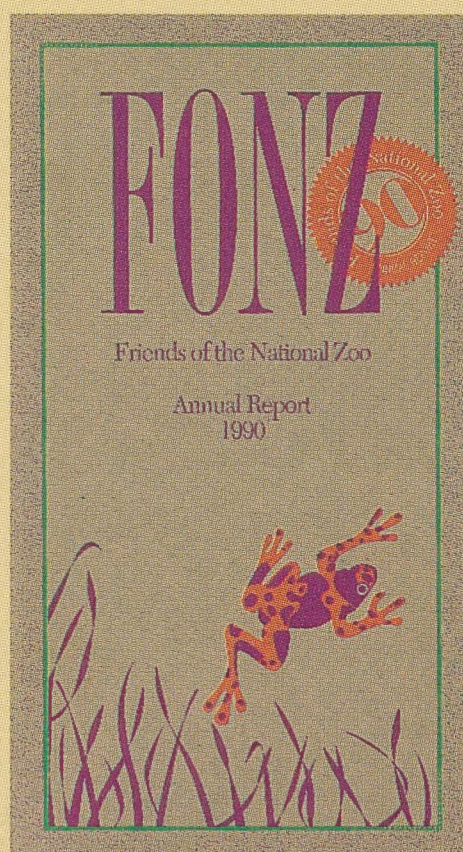
We are especially proud of our growing environmental conservation program. Begun in 1989, this program has two components: educating our members, Zoo visitors, and the general public about environmental conservation, and changing our own practices to ensure that they are environmentally sound. All of FONZ's departments and offices are committed to this program and their achievements are highlighted in the Annual Report. Not noted there is that FONZ has begun to use recycled paper for its stationery as well as for many of its publications.

In this and the coming year, FONZ is also working to expand its membership base, to encourage more families in the metropolitan area to support the Zoo, to spread the word about wildlife conservation, and to enjoy the many benefits of FONZ membership. As part of this effort, FONZ is instituting outreach programs to better promote FONZ and the Zoo among the area's diverse ethnic communities, and to offer more services for the disabled. Within the Zoo itself, FONZ is working to expand and improve all of its services for visitors, and, thus, enhance their total experience of the Zoo.

In the last several years, under the leadership of Director Michael Robinson, the Zoo has undergone some exciting changes for the better. New exhibits, new landscaping, and an entirely new approach have emerged as the Zoo slowly becomes a

BioPark that displays—and educates about—the beauty, complexity, and interconnectedness of the entire living world. FONZ, too, is changing so it can better support this major innovation in the concept of a zoo. The unique partnership between FONZ and the National Zoo is, in 1990, stronger than ever, ensuring great achievements in the decade ahead.

To request a copy of the complete 1990 FONZ Annual Report, please write to: FONZ Annual Report, National Zoo, Washington, D.C., 20008, or call 202.673.4960.



George A. Didden, III
President
Friends of the National Zoo

ZOOGOER

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African antelope batik.
(From a private collection.)

FEATURES

- 4 Spotted Star of the Serengeti:
Four Years in the Life of a Female Leopard**
John A. Cavallo
A scientist's venture into the Serengeti reveals surprising discoveries about a mother leopard and her cubs.
- 12 The Bulldozer and the Butterfly**
Robin Meadows
A compromise in California proves development and nature are not mutually exclusive.
- 15 Pawprints: Tiny Travellers**
Mary K. Miller
Diving into the wonders of baby marine life.
- 19 Maned Wolves: A Disappearing Act?**
Jeffrey P. Cohn
The battle against the population decline of maned wolves— Is a retreat in sight?
- 22 Sex Change in the Tropics or
Why Females Have to be Big to Hang Loose**
Marty Condon
A behind-the-genes look at the sex change of rainforest cucumbers in northern Venezuela.

DEPARTMENTS

- 26** Notes & News
28 Frontiers
30 Books, Naturally
31 The Last Elephant

Spotted Star

Four Years in the Life of a Female Leopard

of the Serengeti

A large hyena maintained a steady, rhythmic gallop just ahead of my Land Rover. On the rutted dirt track bordering the Wandamu River, the bouncing beams of my headlights illuminated its spotted grey body and demonic grin. After a last over-the-shoulder look, it veered suddenly to the right and disappeared into the blackness. Minutes later my lights picked up two glowing eyes and a familiar shape walking toward me in the road. It was an adult leopard. I hit the brakes and the big cat froze about 20 feet in front of me. Even after a year's absence its relaxed response to this chance meeting and its distinctive facial spots confirmed what I hoped was true . . . it was Nyota!

Text and Photos by:

John A. Cavallo

Opposite page: Nyota, a female leopard.



I'd first seen the female leopard in 1987 when I'd come to Tanzania's Serengeti National Park with my graduate advisor, Dr. Rob Blumenschine, for a pilot study on leopards (*Panthera pardus*). At that time, Nyota was about six-and-a-half years old and in the company of her 14-month-old male cub. Her Swahili name, meaning "a star," was given to her by a Serengeti National Park guide who'd also named her male cub "Zawadi," meaning "gift." Nyota is extremely tolerant of vehicles, making her perhaps the most photographed animal in the Serengeti, where she and her cubs have provided thousands of camera-wielding tourists with their first look at a wild leopard. For several years I've followed Nyota and her offspring, observing at close range details of cub-rearing and other behaviors that few researchers have witnessed.

Nyota's home range is in the Seronera

Valley, a patchwork of open acacia woodlands with narrow ribbons of trees and bush bordering the Seronera River and its tributaries. Here and there, clusters of huge rounded boulders known as kopjes (pronounced "copies") protrude like islands in the endless sea of grassland savanna. These riverine woodlands and kopjes provide water, shelter, refuge from enemies, and cover from which the solitary leopard ambushes prey. The big cat's diet is more varied than that of the cheetah or lion and includes insects, snails, rodents, snakes, birds, gazelles, impala, and the young of giraffe and waterbuck. By hoisting its kills into trees, the leopard protects its larder from scavenging by lions, hyenas, and vultures and can leisurely feed on a carcass for several days.

Leopards may hold home ranges for several years and mark them with urine, feces,

claw-marking of trees, and their saw-like call. According to a previous study in the north-east woodlands of the Serengeti, female leopard ranges are a mosaic of relatively small, sometimes overlapping ranges encompassed within a mosaic of more expansive, nonoverlapping male ranges. A female's range might fall within the ranges of up to two or more males. For females, food availability apparently dictates range size, particularly during cub-rearing. Male ranges appear to be affected by prey abundance during times outside the mating period and by the distribution of receptive females.

Like other solitary cats, adult leopards are usually intolerant of one another's presence. Males and females tend only to associate while mating. Gestation averages between 90 and 100 days, and males play no role in the rearing of cubs.

According to a Serengeti guide, Zawadi was the sole survivor of a two-cub litter born to Nyota around June of 1986. The fate of the other cub is unknown, but its disappearance is not uncommon; females rarely raise more than one offspring to maturity, and even this is an accomplishment. In addition to starving during extreme droughts, cubs can fall prey to lions, hyenas, baboons, poisonous snakes, and male leopards.

Zawadi, at about 14 months of age, was nearly the size of his mother and more muscular, but he killed only mice and hares. The hunting of larger prey was left entirely to Nyota. Zawadi demonstrated his inexperience with large prey one day when he sent a tree-stored gazelle kill crashing to the ground, and his mother scrambling down to retrieve it. Later that same evening, his fumbings rained portions of the same kill into the mouths of two hyenas waiting patiently below. But the clumsy young leopard was also showing the signs of independence that precede the permanent separation of mother and cub at 17 to 20 months of age. He would, for example, choose his own resting tree to escape the blazing midday sun or wander off several kilometers from his mother at dusk.

In addition to the round-the-clock threat of lions and hyenas, during daylight hours leopards must also deal with a somewhat smaller, but nonetheless ferocious adversary, the olive baboon. One afternoon we were watching Nyota and Zawadi as they rested in two fever trees after snacking on a gazelle kill. As we ate our own lunch of canned tuna, a local troop of 37 baboons, including several large adult males, marched warily past our vehicle on a foraging excursion. Suddenly, two of the males reared up, looked toward the fever trees, barked out several alarm calls, and, with canines bared,

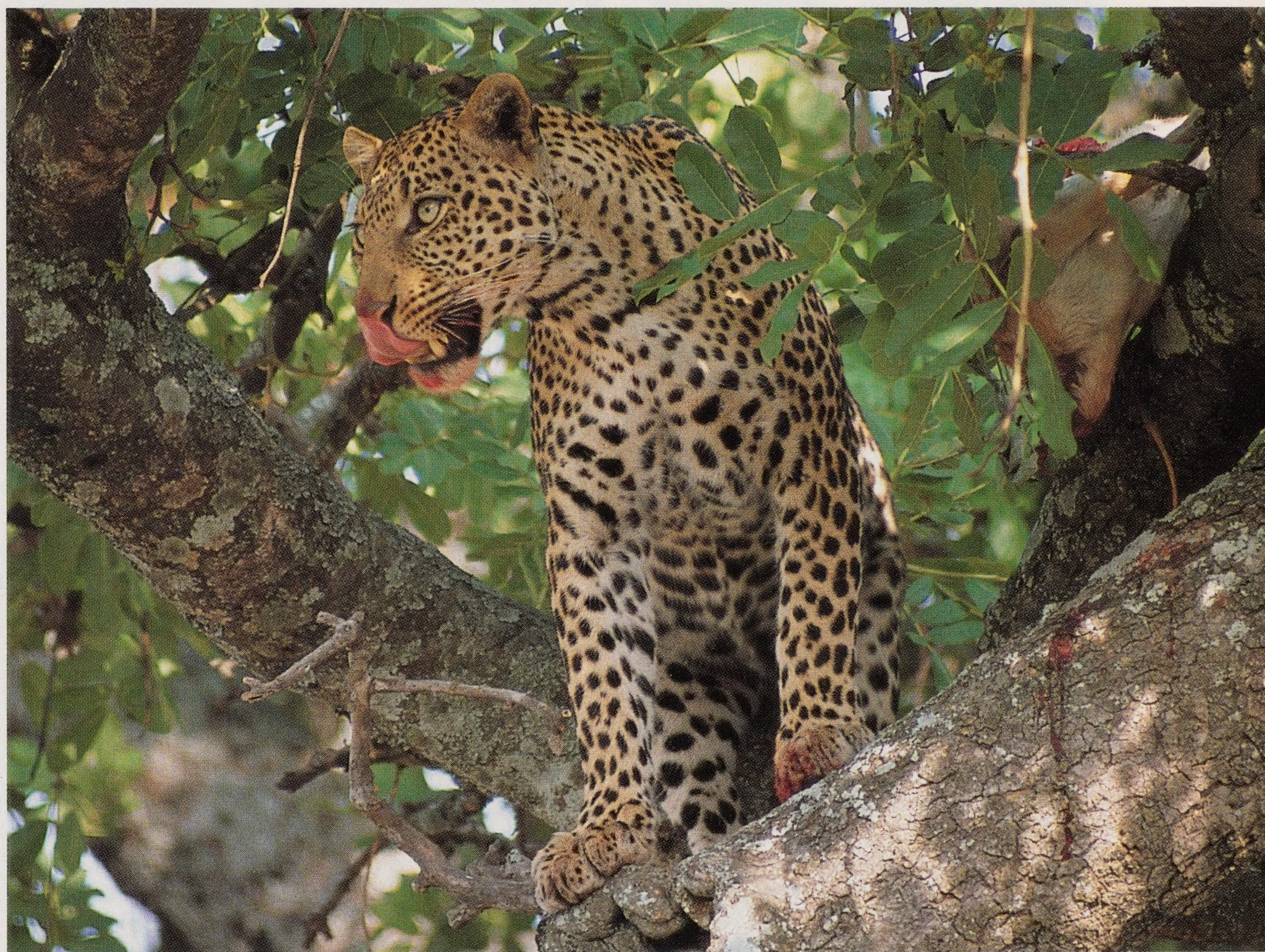


Young calves of giraffe and other ungulates are vulnerable to predation by leopards.

charged toward Nyota and Zawadi with the rest of the troop close behind. The two leopards leapt from their trees and disappeared into the dry bed of the Wandamu River. Ignoring the tree-stored kill, the baboons instead dined for several hours on nutritious acacia pods in two nearby trees. Soon after the baboons had left for their sleeping grove, Nyota returned alone to her tree-stored kill. From there she surveyed in all directions and, with a series of short, deep, saw-like “coughs,” called to her cub. She kept this up for nearly 45 minutes between intervals of feeding on the carcass. Finally, Zawadi appeared at the base of the tree, climbed to the limb where his mother waited, and they nuzzled and licked each other affectionately.

Although Nyota and her cub had fled the baboon onslaught, when the sun sets on the Serengeti, it's the baboons' turn to cower in their sleeping trees. For under the cover of darkness, leopards can slip into these trees and kill baboons with relative ease. Early one morning just before my arrival, wildlife filmmakers spotted Nyota dragging the carcass of a large adult male baboon near one of the primate's favored sleeping groves on the Wandamu River.

After a month in Africa I was enthusiastic about continuing my study of leopards, so I returned to the States to apply for funding. I received grants from the National Science Foundation, the L.S.B. Leakey Foundation, and the Explorers' Club, and Edward and Marylin Collett. With permission and support from the Tanzanian National Parks and the Serengeti Wildlife Research Institute, I came back to Seronera in July 1988, during the dry season. I hoped to determine the number, age, and sex of leopards within a 150-square-kilometer area around Seronera; to document the sizes of their ranges; and to collect data on their diet, cub-rearing behavior, and interactions with other predators and ba-



Male cub, one of the “Kopje cats.”

boons. After finding Nyota on my first night back, wildlife filmmakers reported that she'd been seen mating with a large male in late March and was thought to have given birth in June. Her den, they said, was in the Masai Kopjes, a large complex of boulders between the headwaters of the Wandamu and Seronera rivers. Zawadi (then just over two years old) had left his mother and was living in an adjacent portion of the Seronera River.

I began following Nyota's daily treks to and from her den in a large bush-covered opening in the rocks some 10 meters above the ground. During that period, she restricted her hunting excursions, staying within a

one-to-four kilometer radius of the den. She often spent hours patiently prowling the parched grassland and patches of bushes in search of hares, which responded to her by freezing. Nyota simply walked up, plucked one from the grass with her powerful jaws, and carried it to the shade of a bush to consume, bones and all. Another favorite prey is hyrax, a small rodent-like distant relative of the elephant that lives in groups among the rocks and bushes of kopjes. I once saw Nyota spring more than three meters from a tree limb and crash into a thick bush that exploded with small grey bodies; emerging with a hyrax in her mouth, she ate it on the spot

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amidst a chorus of chirping alarm calls.

Although I saw Nyota almost daily, it was several weeks before her cubs emerged from the den. One morning, my wife Roberta and I watched Nyota feed on the leftovers of a Thomson's gazelle, high in a fever tree on the Seronera River. After several hours, she left the tree and made her way to Masai Kopjes. As she approached the den, two dark growling cubs, a male and a female, appeared. She nuzzled and licked them and led them to a large flat rock outside the den entrance, where the cubs nursed. Afterwards, Nyota rested while the "Kopje cats" (as I'd dubbed them) wrestled, pounced at lizards and insects, and used their mother as a plaything. Nyota was usually very affectionate and tolerant with her cubs, but sometimes the cubs' constant pestering and painful ear-nipping became too much for her and Nyota would growl loudly and bare her massive canines. When Nyota left on a hunt or to feed on a kill along the river, the otherwise noisy, active cubs remained hidden behind, absolutely silent for up to seven hours at a time to avoid discovery by prowling lions.

During the first two months of their lives, the cubs' only nourishment was mother's milk. Then I began to see signs that they'd begun eating meat. At first, the evidence was indirect: Nyota carrying scraps of gazelle and smaller kills back to the den. Several weeks later, while Nyota was stalking a small herd of topi, my suspicions were confirmed. At the entrance of a new den, I saw the male cub with the body of a young topi calf in his mouth.

A few days later, the cubs accompanied Nyota on their first excursion to the Seronera River. While she hunted, the cubs hid in the hollows of trees or under low bushes, waiting to be fed. During that week, she brought the cubs a small python she'd killed as well as a large Egyptian mongoose. These kills were fed on first by the cubs.

With larger prey, such as Thomson's gazelles and reedbuck, Nyota would feed first, then bring her cubs to the kill. At first, the cubs were awkward when climbing or descending their mother's storage trees or feeding on large carcasses. But their skills and confidence grew daily. As the cubs included more and more meat in their diet, the frequency of their suckling diminished, until they were fully weaned at about six months old.

No longer anchored to a den by her cubs, Nyota now extended her hunting forays farther west to the confluence of the Seronera and Wandamu rivers, where small herds of migratory Thomson's and Grant's gazelles congregated during the dry season. This increased her range to 38 square kilometers,

bringing her into closer proximity to another female with a young male cub and to a large, old, adult male. The western part of Nyota's range also overlapped with that of her grown male cub, Zawadi, whose territory spanned a minimum of 28 to 30 square kilometers. While Zawadi's prowlings frequently brought him to less than a kilometer of his mother, I never saw them together.

The last time I saw the Kopje cats was in October 1988, when their usually tranquil life was shattered by a troop of baboons. Mother and cubs were resting peacefully when the troop approached unawares and began barking loudly. Nyota and her female cub escaped into the tall grass, while the male scrambled high into the canopy of a tree. The baboons eventually left without harming the cub.

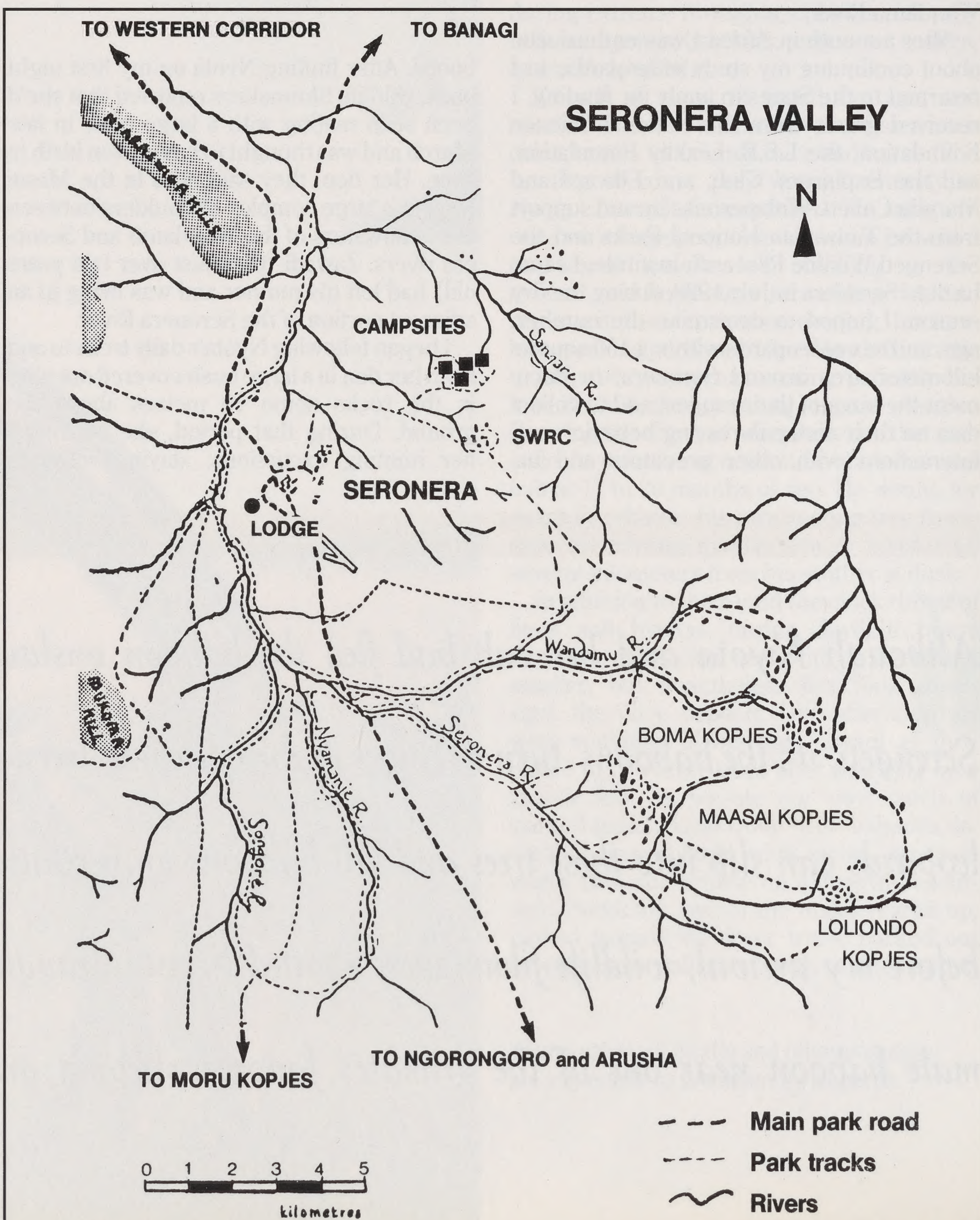
I received word after being back in the States for a while that one of Nyota's cubs had been missing since June of 1989. Since it was then a year old and still dependent on its mother, the cub was presumed dead. Nyota was seen mating again in August, which suggested she'd also lost her other cub. Return-

ing to the Serengeti in February of this year, during the wet season, I was able to catch up on news of Nyota and her cubs by reading the detailed notes that wildlife filmmaker Vicky Stone had kindly kept for me while she and Mark Deeble filmed the leopards in December 1988 and January 1989. I searched in vain for Zawadi and for Nyota's younger cub for several weeks after my arrival, then turned to Vicky's notes for answers. They provided important clues to the disappearances and revealed some astonishing leopard behavior.

While I was gone, Nyota had shifted her hunting range farther west to the Nyamanga River, a tributary of the Seronera where Zawadi lived. Early in January, Vicky and Mark found Nyota in a tree; below her on the ground was a large, unfamiliar male leopard. Salivating heavily, the transient male sprang into the tree with Nyota and they snarled fiercely at one another. Nyota soon retreated and, leaving the male behind, collected her cubs and left the area.

That same night, a rarely documented and

Map showing Nyota's range and surrounding area.





Leopards spend a surprising amount of time in trees, resting and feeding.

surprising event occurred: Nyota and her cubs were joined by Zawadi. Why he should appear and why Nyota tolerated his presence around the younger cubs was puzzling. Although chance meetings between mothers and grown cubs occur, these are most frequently between females, who tend to live close to their natal ranges for most of their lives. Young males, however, are usually driven out fairly early by older, more powerful rivals. The possible answer to this unusual behavior came later that night, when the

large male leopard returned and chased the four of them off a kill. I believe that the transient male was pressuring Zawadi out of his own hunting territory, forcing the younger male into closer proximity to Nyota.

The next morning, Zawadi climbed one of Nyota's storage trees and fed on a Thomson's gazelle, side by side with one of the cubs. Nyota called to the small cub, who climbed down the tree and wandered off with its mother and sibling. Later, Nyota returned to the tree where Zawadi had left the kill and

began nibbling at tidbits around the base. As Zawadi approached her, Nyota leapt into the tree. He followed her and they snarled aggressively at one another, but eventually settled down on different branches to feed. Zawadi left the area soon after.

The following day, Vicky observed Zawadi drop a Thomson's gazelle kill by the base of a tree and disappear into some nearby bushes. Suddenly, he bolted away, pursued by the large, unfamiliar male leopard who chased Zawadi for nearly three kilometers before he

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returned and flushed Nyota's female cub out of her hiding place along the river bank. The frightened cub scurried up a tree and crouched on a low branch as the big male approached. He drew closer, stopped, then turned and walked away. Later, Nyota recovered the partially eaten gazelle that Zawadi had abandoned and brought it to her cubs. The large male returned and she dropped the carcass to the ground, where all appeared to feed on it. The four leopards remained together until sunset.

Two weeks later, Nyota and her cubs were seen in a tree and the big male was in an adjacent tree feeding on a kill he'd appropriated from her. Several days later she was seen in a tree with Zawadi sharing portions of a Thomson's gazelle. This comingling of leopards feeding together is, to my knowledge, extremely rare.

Although I never found Zawadi this year, I did see a large male leopard in prime condition that I believe to be the "stranger" observed by Vicky Stone. His range, as best I could determine, overlaps a major portion of Nyota's present range and the former range of Zawadi. It seems that the new male finally succeeded in driving Zawadi out of the area. Toward the end of my field season this year, two Tanzanian safari guides reported that they'd seen a large leopard kill the male "Kopje cat" cub in June 1989. Sadly, another guide told me he'd found the carcass of the female cub shortly after, her head crushed, draped over a tree limb on the Nyamanga River.

The evidence is circumstantial, but it suggests that both cubs were the victims of infanticide. Given the overlap in Nyota's and the transient male leopard's ranges, he appears to be the most likely individual to have killed the older cubs and fathered the new male and female cubs born to Nyota in late 1989. Infanticide in lions, tigers, and other species is thought to be a reproductive strategy used by males to terminate a female's investment in cubs they've not sired. Killing cubs quickly brings a female into estrus and reduces the time a male must wait to father his own offspring. Among Serengeti lions, which are social carnivores, infanticide seems to occur fairly rapidly after a male makes contact with a new cub-rearing female. But this was apparently not the case with Nyota and the new male leopard. If indeed he did kill Nyota's cubs, why did he wait nearly five months to do so? Unfortunately, this question must remain unanswered.

Nyota's latest litter was named the "sausage-tree cubs." They were reportedly born in the hollow of a sausage tree on the Seronera River in late November or December of 1989, at the beginning of the rainy season. During the initial short rains, Seronera starts its metamorphosis from a sun-scorched, tawny landscape to a lush green valley. By



A male baboon (*Papio cynocephalus*) can kill leopards during the day, but at night the roles are reversed.

February, the skies fill with ominous, moisture-laden clouds and the wet season is heralded in Wagnerian fashion with huge curtains of rain moving slowly over the savanna to the accompaniment of flashing lightning and loud rolling thunder. Rushing water spills over the banks of once-dry river channels and dusty black cotton soil becomes a soupy, slippery tar. The stubbles of grass have turned green and reach hip-high proportions, and the shaded bases of umbrella acacias explode with blankets of white and yellow flowers. However, in the midst of this transformation, animals are less abundant and more widely dispersed than in the dry season. When the rains begin, the small herds of Thomson's and Grant's gazelles—Nyota's prey—vanish along with the legions of wildebeest, zebras, and other gazelles. The herd animals move south to the shortgrass plains where, more than a million and a half strong, they mass annually.

Left behind are year-round residents, scattered few and far between throughout the valley. Families of warthogs scurry about with skinny tails held high. Herds of graceful female impala, tended by single territorial males, dot the open woodlands. Huge black hulks of mean-tempered buffalo with massive curled horns peer from bushes. Waterbuck and the secretive reedbuck feed nervously in the dense riverine vegetation. Tiny groups of topi and hartebeest graze in the open, while the necks of stately giraffe glide by like the masts of great sailing ships through the trees and brush. During this year's rainy season, the resident "campsite" lion pride focused on lone buffalo while Nyota turned her attention to smaller prey: reedbuck and calves of waterbuck and giraffe, which she stalked from the tall grass by the river.

Late in February of 1990, a fascinating change occurred in Nyota's behavior. Earlier in the month she'd successfully killed several

reedbuck and stored them in trees along the Seronera. Near month's end Mark Deeble and I found her and the sausage-tree cubs with the carcass of a giraffe calf he'd filmed minutes after its birth on the previous afternoon. She'd killed it during the night and dragged the 150-pound carcass 60 feet to the base of a fever tree where she and her cubs fed on it for nearly five days. Much to our surprise, Nyota never took the carcass into a tree and hyenas never scavenged the kill.

At the same time, a large male leopard, with a prominent break at the end of his tail, was living a considerable distance downstream from Nyota. He'd been hunting impala and had also taken an adult male baboon. Unlike Nyota, he carried all of his kills into trees. Why did he go to this trouble while Nyota dined on the ground?



Rainstorm in the Serengeti.

I found clues to the leopards' behavior in the black cotton soil bordering the river. In the early morning, after a rain, the mucky roads abound with the footprints of nocturnal animals, providing a valuable record of the movements of leopards and their major com-

petitors—lions and hyenas. In Nyota's range, I'd consistently seen the night tracks of just one hyena and only rarely did I record any lions. (From mid-February to early May I'd seen only four adult lions in the area.) In the area occupied by the broken-tailed leopard, both sightings and tracks of hyena and lion were common. Since the tree-caching behavior of leopards is prompted by the presence of large carnivores, their absence in Nyota's range explained why she didn't bother to remove her kills from their reach.

Still, I was puzzled about why there were so few lions and hyenas in Nyota's territory. With the help of colleagues from the Serengeti Hyena Project and the Serengeti Lion Project, we pieced together the answers. First, the cessation of tree-caching by Nyota during mid-February coincided precisely with the time when most female wildebeest drop their calves on the shortgrass plains 60 to 70 kilometers away. For the next few months, the plains become a living banquet table for the predators and scavenging vultures of the Serengeti.

Working with radio-collared animals, Herbert Hofer and Marion East of the Serengeti Hyena Project tracked hyena clans whose dens are located in Nyota's area and in other parts of the Seronera. They found that, during this time, the hyenas in Nyota's range "commuted" to the plains to hunt among the wildebeest, zebra, and gazelle herds, making the 140-kilometer trip twice a week. However, members of a hyena clan in the range of the broken-tailed male tended to remain in the area, opting instead to scavenge scraps of food left by humans or leftovers from buffalo kills made by the "campsite" lions. According to Jon Grinell and Craig Packard of the Serengeti Lion Project, the paucity of lions in Nyota's range was due to the breakup of the once-large "Seronera pride," which formerly occupied the area for



Leopard cubs start feeding on kills at two to three months.

many years. As long as the density of lions and hyenas in Nyota's range remained low, she could consume her prey on the ground without fear of losing to competitors.

The last time I saw Nyota and the sausage-tree cubs, she was leading them down the rain-soaked Seronera River road in the late afternoon. They paused by a large puddle and lapped at the water. While the cubs alternated between drinking and growling at each other, Nyota stood with her head high and sniffed the wind. She called once to the cubs and the trio headed into the tall grass toward the river. I climbed out through the roof hatch of my vehicle and watched until the white underside of her tail disappeared from sight. By mid-May the migratory herds had returned to Seronera on their way to the Masai Mara in the north, once again completing the annual cycle. Nyota and her new cubs were fit and ready to face another yearly event: the legions of tourists who'd soon arrive with cameras in hand in the hopes of glimpsing the spotted star of the Serengeti. ♣

John Cavallo has spent the last four years studying leopards in the Serengeti and working toward his Ph.D. in anthropology at Rutgers University.

During the initial short rains, Seronera starts its metamorphosis from a sun-scorched, tawny landscape to a lush green valley. By February, the skies fill with ominous, moisture-laden clouds and the wet season is heralded in Wagnerian fashion with huge curtains of rain moving slowly over the savanna to the accompaniment of flashing lightning and loud rolling thunder. Rushing water spills over the banks of once-dry river channels and dusty black cotton soil becomes a soupy, slippery tar.

Developers and environmentalists cooperate to
protect an endangered butterfly.

Robin Meadows

Most of the hills south of San Francisco bristle with rows of identical houses, a far cry from the coastal grassland that once flourished on the peninsula. A remnant of this wildflower-rich habitat survives, however, on a gently sloping mountain just outside of the city. Conspicuous for its relative lack of development, San Bruno Mountain is also striking for a reason not obvious to the eye: Its grassy expanse is virtually the last home of the Mission Blue butterfly. Listed as endangered in 1976 due to habitat loss, the fingernail-sized, iridescent blue butterfly faced losing much of its remaining habitat in the late 1970s, when the development company that owned two-thirds of the 900-foot mountain proposed building homes and office space there.

Since then, however, the conflict between the developers and the butterflies has been resolved to their mutual benefit. Local environmentalists and the developers worked out a compromise that allowed the developers to build on part of the butterfly habitat in exchange for concessions that protected the remainder. The compro-

mise, called a Habitat Conservation Plan (HCP), protects the butterfly as well as the 16 other rare and endangered species that live on the mountain.

Serendipitously, the San Bruno Mountain HCP has also benefited endangered species and private landowners across the country. Before the plan's completion in 1982, development on San Bruno Mountain might have been held in check by the U.S. Endangered Species Act. But in 1982, the Act was up for review by Congress, and the team that negotiated the San Bruno Mountain HCP persuaded Congress to amend the Act to provide a legal basis for HCPs. The amendment allows the incidental "take" of



Female Mission Blue butterfly (*Icaricia icarioides missionensis*).
(Photo courtesy of Thomas Reid Associates.)

an endangered species, normally prohibited by the Act, as long as this take will ultimately enhance the species' chances of survival. The negotiators who formulated the San Bruno Mountain plan thus paved the way for similar plans. Since 1982 two more HCPs have been completed: one for the wood rat and cotton mouse in North Key Largo, Florida; and another for the Coachella Valley fringe-toed lizard near Palm Springs, California. In addition,

THE
BULLDOZER
and the Butterfly

California has nearly 20 HCPs in progress for species including Smith's blue butterfly, the Valley elderberry longhorn beetle, the least Bell's vireo, and Stephens' kangaroo rat.

HCPs are concentrated in California in part because it has more endangered species—80 in 1988—than any other state. According to Christopher Nagano of the U.S. Fish and Wildlife Service Endangered Species Office in Sacramento, there are two main reasons for this. First, the state is being developed extensively to accommodate the rapidly growing human population, which is expected to increase by 20 percent from the current 29 million to 35 million by early in the next century. Second, California has the most endemic species (those that are found nowhere else) because it has the greatest variety of habitats, ranging from the snow-capped Sierra Nevada mountains, to the Death Valley desert where temperatures soar well above 100° F, to the north coast forests where about 120 inches of rain fall each year. Many of California's endemic species have such specific habitat requirements that, like the Mission Blue butterfly, they are restricted to relatively small areas. Thus, as Californians develop land, they crowd out increasing numbers of endemics.

The Mission Blue is one of a dozen subspecies of the Lupine Blue butterfly, which lives in discontinuous populations through much of the western United States and southwestern Canada. According to recent

estimates, the size of the butterfly's annual population on San Bruno Mountain ranges from 18,000 to 37,000, rising and falling in response to variation in natural factors such as rainfall that affect the growth of the butterfly's food plants. However, because each adult lives only for about a week, there are just a few hundred to a thousand on the mountain on a given day during the spring flight season, when the Mission Blues flit across the San Bruno Mountain grasslands to lay their eggs on lupines. These white-to-purple wildflowers are the sole food source for Mission Blue caterpillars.

Although San Bruno Mountain provides one of the last Mission Blue habitats, it is far from pristine. Cattle grazed the mountain from the mid-1800s until recently, facilitating the growth of introduced, non-native weedy grasses, which spread faster than and thus replace native bunch grasses and wildflowers.

But by the mid-1970s only about 200 of the mountain's 3,600 acres had been developed—even though the mountain's proximity to San Francisco makes it tremendously valuable real estate—thanks in part to the efforts of a local environmental group called the Save San Bruno Mountain Committee. In 1975, however, the committee faced one of its most serious challenges: Visitacion Associates, which then owned 70 percent of the mountain (nearly 2,500 acres), proposed building 8,500 homes and two million square feet of com-

mercial space there. In the battle over development, Visitacion eventually agreed to give up much of its land to the existing county park, and in 1978 sold and donated to San Mateo County a total of about 1,700 acres. This land contained nearly all of the main ridgeline and was too steep to develop anyway. In return, the San Mateo County Board of Supervisors agreed to consider allowing Visitacion to build on its remaining 800 acres.

Opposition from the Save San Bruno Mountain Committee remained as strong as ever, however, until 1980, when Lindell Marsh, an attorney representing Visitacion, Thomas Adams, attorney for the Save San Bruno Mountain Committee, and Edward Bacciocco of the San Mateo County Board of Supervisors began negotiating a plan that would both protect the Mission Blue butterfly and allow Visitacion to develop some of its land. With funds from Visitacion, the county hired a local environmental consulting firm, Thomas Reid Associates, to assess the needs of the Mission Blue butterfly. Completed in 1982, this study served as the basis for the compromise that was later worked out by a committee whose 14 members included representatives of the U.S. Fish and Wildlife Service, attorneys Marsh and Adams, biologists from Thomas Reid Associates, and representatives of San Mateo County.

Biologists from Thomas Reid Associates found that the butterflies need both habitat

Infrared photograph showing massive development around San Bruno Mountain. (Photo courtesy of Thomas Reid Associates.)



protection and habitat improvement. The grasslands that the butterflies require are being invaded by native shrubs as well as by exotic plants, notably eucalyptus, menthol-scented trees from Australia, and gorse, a thorny bush from Scotland. By comparing a 1932 vegetation map of San Bruno Mountain to one from their 1981 study, the biologists found that about half of the mountain's grasslands had been replaced by the invading plants. They predicted that unless this alarming rate of habitat loss was checked, the Mission Blue would go extinct on the mountain within the next 200 years, even with an outright ban on development. Saving the butterfly, they said, would require saving the grasslands—and that would require spending money to clear out the plants that don't belong. In other words, what the Mission Blue really needed was a conservation plan that provided a source of money.

Under the San Bruno Mountain HCP, Visitacion is paying about \$50,000 a year to support San Mateo County's initial efforts to preserve the mountain's grasslands. Ultimately, fees from people who live or work in Visitacion's developments will fund the county's work on the mountain. The county expects to receive about \$60,000 a year, based on annual fees of \$20 for a home and \$10 per square foot for nonresidential development. In addition, Visitacion donated an additional 450 of the 800 acres of land it then owned to San Mateo County, adding to the county park the richest then-unprotected Mission Blue habitat on the mountain. In exchange, the Fish and Wildlife Service is allowing Visitacion to develop its remaining land on the mountain, even though this land is about a tenth of the Mission Blue habitat.

San Bruno Mountain has two east-west ridges separated by a saddle. The Mission Blues live primarily on the ridges. About 60 percent of the population lives on the southern ridge and about 30 percent lives on the northeast ridge. Visitacion proposed to build two developments on the mountain. The first is on the slope below the southern ridge and so should have a minor impact on the butterflies. Accordingly, the South Slope Project was approved for development of about 700 homes and 350,000 square feet of commercial space, and the developer began grading



Habitat Conservation Plans are in progress to stem the decline of least Bell's vireo (*Vireo bellii pusillus*). (Photo by B. "Moose" Peterson.)



Callippe fritillary butterfly (*Speyeria callippe*), another resident of San Bruno Mountain and candidate for the endangered species list. (Photo courtesy of Thomas Reid Associates.)

this 126-acre parcel in the spring of 1989. In contrast, development proposed for the northeast ridge would affect the butterflies directly, and this made it comparatively difficult for Visitacion to come up with an acceptable development plan. In 1989, however, the local city government approved a Northeast Ridge Project plan for 590 homes—fewer than half of the 1,250 homes originally proposed for the 92-acre parcel. Fish and Wildlife Service approval of this project is now pending.

To minimize the impact of the Northeast Ridge Project, Visitacion plans to divide the development into four areas that are well separated by corridors of grassland habitat. The corridors will allow the butterflies to fly relatively freely across the development and will keep the population from being fragmented into isolated subpopulations, which is important because smaller populations are more susceptible to being wiped out by factors such as disease and predation.

In both projects, Visitacion will take three further measures to minimize the effects of development on the butterflies. First, the company will develop the land over a period of several years. For example, by grading part of the land one year, another part the following year, and so on, Visitacion will spread the effects of development over several generations of butterflies, which should reduce the impact of habitat loss on the population as a whole. Second, Visitacion will minimize erosion by constructing the buildings during the dry season. Finally, the company will reclaim areas such as access roads, which will be graded in the course of construction but will not be permanent parts of the developments. An estimated 100 acres of the disturbed habitat will be reclaimed by measures such as replanting the wild grasses and wildflowers that the Mission Blues depend on. Fortunately, grassland plants tolerate perturbation. In fact,

some, such as lupines, actually require natural disturbances like mudslides or fires to establish their seedlings because they compete poorly with established plants.

Besides requiring habitat reclamation in construction zones, the HCP calls for preserving and enhancing butterfly habitat in the 2,800 acres of the mountain that will remain as open space. As Thomas Reid Associates points out, preservation is preferable to enhancement, which entails manipulation and so may have unforeseen—and undesirable—results. But because some habitat enhancement will be necessary, the firm's biologists are testing enhancement techniques that range from the conservative, such as sowing seeds of native plants, to the extreme, such as using herbicides or a flame thrower to eradicate invading gorse. To see whether a technique actually enhances the butterfly habitat, the biologists are proceeding cautiously. For example, the biologists burned about 12 acres of gorse and other exotics in 1989, and over the next two years will determine how many non-native plants sprout back in the burned area.

To determine the success of the HCP as a whole, Thomas Reid Associates censuses the butterfly population every year. As long as the population is stable or increasing, the plan is probably working and so far, so good: Since 1981, estimates for the Mission Blue population have been near or well above the initial 18,000. The San Bruno Mountain HCP has shown that, paradoxically, wildlife can actually benefit from development. Marsh, the attorney for Visitacion who conceived of and helped work out the plan, believes the existence of HCPs shows that "people hunger for workable solutions to wildlife problems and want to cooperate." ❀

Robin Meadows is a contributing editor to ZooGoer.

TRAVELLERS

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Mary K. Miller
Illustrations by George Reyes

At first glance, many marine invertebrates seem like cruel parents. These animals without backbones cast their tiny, barely developed offspring into the sea to scatter like dandelion seeds on the wind. But for some animals that live most of their lives on a small section of rock, kicking out their young is a biological necessity. By drifting far and wide with the ocean currents, the microscopic youngsters, called larvae, colonize new areas.

The spreading of individuals to new areas is called dispersal. The way animals disperse their larvae in the sea is similar to the way plants disperse their seeds on land. New generations are dispersed so they don't compete with their parents for food and space. Dispersal also brings genetically different individuals into a region and strengthens the gene pool.

Like plants, most marine invertebrates do their long-distance travelling only at the beginning stages of their lives. Some of them, like the larvae of barnacles, may cross an ocean before they become adults. Barnacle larvae can live for months in the open sea, but other invertebrates, like corals and anemones, exist as larvae for only a few hours or days.

However long they drift, just a few of the thousands to millions of

larvae from each set of parents will survive the perils of the open sea. Most of them will be gobbled up by hungry fish or invertebrates or forced by currents into inhospitable environ-

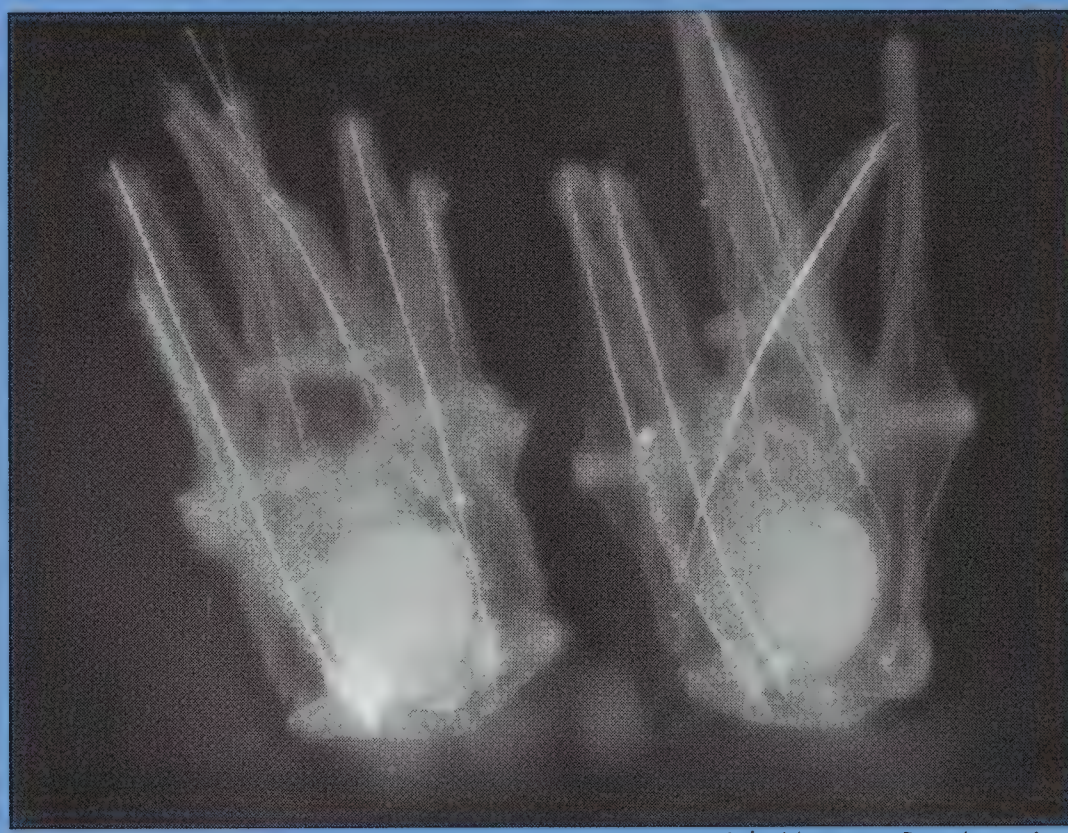
ments. But occasionally, a lucky larva will come across a suitable home, where it can settle out of the currents and become an adult.

The transformation from larva to immature adult, or juvenile, is called metamorphosis. No one knows for sure all the conditions necessary to trigger this change. Water temperature, day length, suitable rocks, sand, or other surfaces, and the

presence of food and certain plants and animals, including their own species, may all contribute to the complicated set of "settling cues" for each species.

Caterpillars shut themselves up in a cocoon to change

into butterflies, but marine larvae go through metamorphosis out in the open. Some of the changes occur even before the larvae settle out. For example, gastropod snail larvae, called veligers, start to absorb their swimming paddles into their bodies while still drifting in the currents. Echinopluteus, the larva of a sea urchin, starts developing its spiny adult form *inside* the larval body even before it finds a patch of rock or sand on which to settle.



copyright Monterey Bay Aquarium



Top: *Echinoplutei* larvae of the deep sea urchin. (Photo by Sue Lisin.) Bottom: Adult deep sea urchin, a bottom dweller. (Photo by David Wrobel.)

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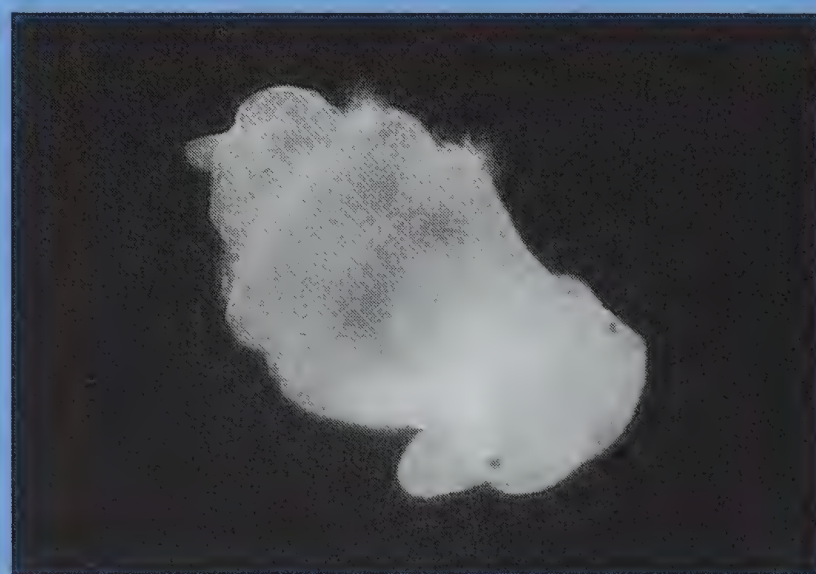
THE DOUBLE LIFE

Marine invertebrate larvae come in many fantastic shapes and most look very different from their parents, just as caterpillars look very different from the butterflies they become. The reason invertebrates change so much is because they really live two different lives in one. As larvae, they drift among the other animals and plants of the open ocean like soap bubbles from a bubble machine; as adults, many invertebrates are immobile bottom dwellers.

Larvae are well adapted for the open ocean. They are small, most no larger than a grain of rice, which helps them stay afloat.

To move up and down in the water, planula and veliger larvae (see illustrations on the next page) wave bands of short bristle-like hairs called cilia. Zoea larvae have legs instead of cilia to help them get around.

The ocean is a dangerous place and larvae have evolved ways to protect themselves from predators. Many are transparent, making them almost invisible in the water. Some larvae, like zoea and pluteus, have long spines, making them a prickly, hard-to-eat meal.



Larva of the segmented polychaete worm, *Chaetopterus*. Polychaetes are marine relatives of earthworms and leeches.

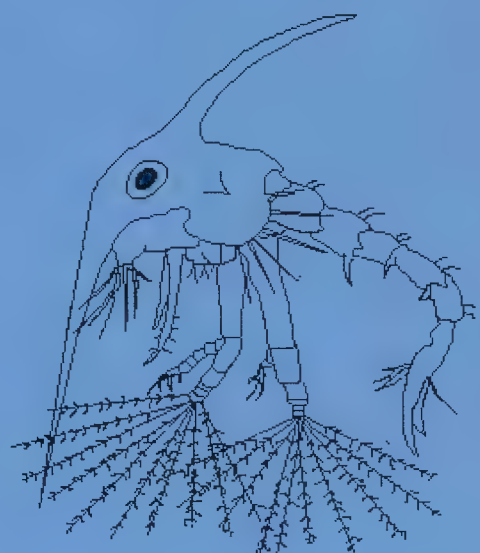
(Photo by Mary Rice, Smithsonian Institution.)



See if you can match each larva with the adult invertebrate it will become.

+ Larva

+ Adult



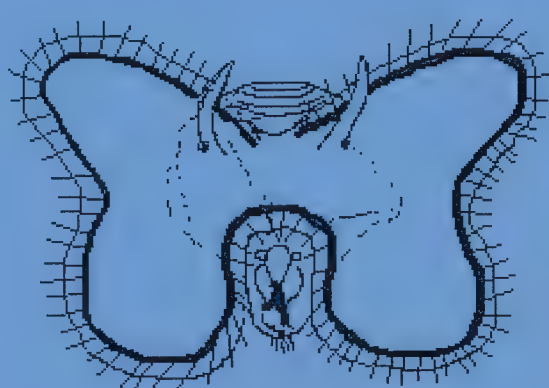
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(Zoea) This youngster will scamper sideways when it grows up.

Brittle star



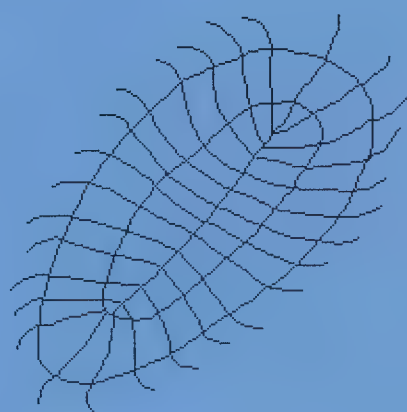
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(Veliger) As an adult, this invertebrate will protect its soft body with a sturdy home.

Sea anemone



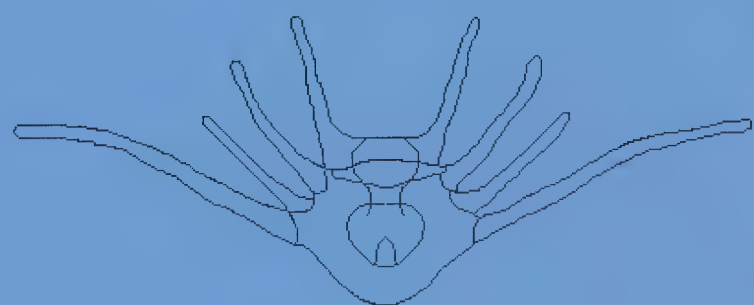
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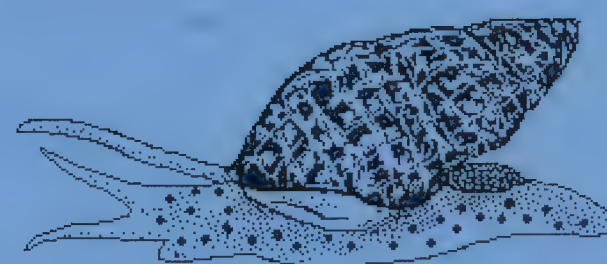
(Planula) This football-shaped larva will settle down to grow lots of appendages for capturing prey.

Cancer crab



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(Pluteus) This intricate baby will grow into an adult with a five-part body plan.

Gastropod snail

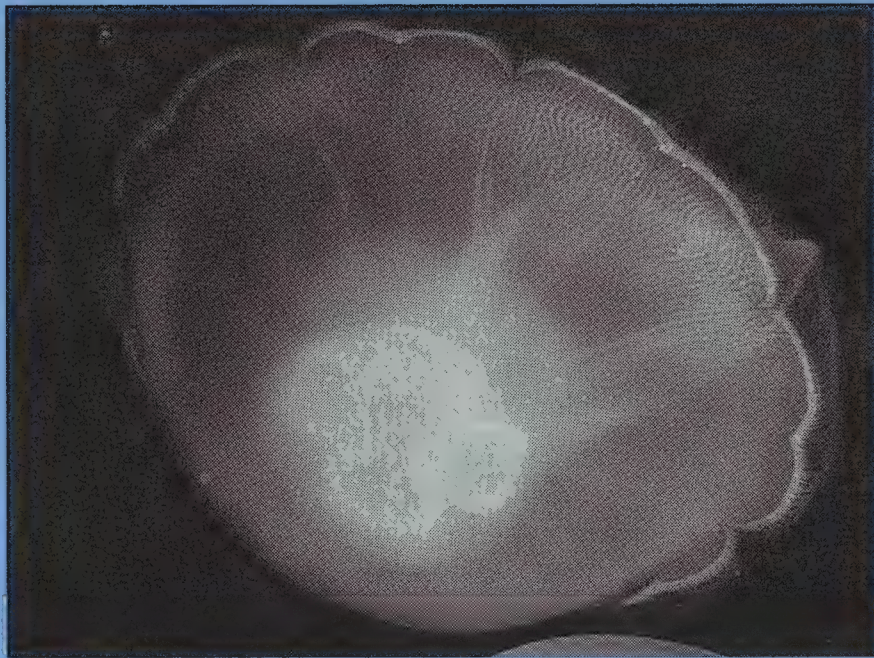
Answers: Zoea-Crab; Pluteus-Brittle star; Veliger-Snail; Planula-Anemone

DRIFTERS

Plants and animals that are swept along by the currents of the open ocean are called plankton. The word plankton means drifter or wanderer. Unlike fish and marine mammals, which have fins and strong muscles for swimming, planktonic animals have almost no control over where they go.

There are two types of plankton: Phytoplankton are the microscopic plants of the sea, and zooplankton are the animals.

Some zooplankton are very small, like the microscopic larvae of invertebrates and fish, or copepods, shrimp-like creatures about the size of a rice grain. Others are larger, like jellyfish that can grow up to 10 feet in length. Krill, thumb-length planktonic animals related to shrimp and prawns, feed the world's largest animal, the blue whale. Instead of teeth, blue whales have special filters, called baleen, which strain huge amounts of the



small red krill out of the water.

Krill, jellyfish, and some copepods remain drifters for their entire lives, unlike larvae that are only temporary inhabitants of the open ocean. The most important plants of the sea, the phytoplankton, also float and bob their life away.

Just like plants on land, phytoplankton, such as diatoms and dinoflagellates, form the base of a complex web that provides oxygen and food for all the ocean's animals. Because diatoms and dinoflagellates are so small, only larvae and the tiniest adult invertebrates and fish feed directly on them. But these small animals are food for larger animals, which in turn feed even larger animals, all the way up to killer whales and humans.

Top: The moon jellyfish drifts in the open ocean its entire life. (Photo by David Wrobel.) Bottom: The shrimp-like krill, a planktonic animal. (Photo courtesy of the National Science Foundation.)

DANCERS



Not all plankton come from the ocean. Ponds, rivers, and lakes also have microscopic worlds that thrive in a single drop of water. Collect some pond water in a jar and look at it through a magnifying glass. If you have a microscope, place a drop of the water on a slide. You should see dozens of tiny animals swimming around with single-celled plants.

MANED WOLVES:

Jeffrey P. Cohn

Jim Dietz splashed in a gushing stream, rinsing off the dust and dirt of a long day spent following maned wolves through Brazil's billowing grasslands. Then a movement on the stream bank caught his eye. There, just 20 feet away, stood one of the elusive wolves, watching his erstwhile watcher. For a few fleeting seconds, Dietz and wolf silently eyed each other, neither daring to move until the wolf abruptly turned and disappeared into the bush. Just as, now, the maned wolf may be quietly disappearing from its natural habitat and from zoos.

When Dietz was studying maned wolves 10 years ago, their prospects for survival seemed promising. While habitat loss and other factors had greatly reduced the maned wolf population in its South American range, its numbers appeared to have stabilized. Maned wolves enjoyed the protection of being listed as endangered by the governments of Brazil and the United States, and trade in maned wolves was regulated by the Convention on International Trade in Endangered Species (CITES). Moreover, zoos worldwide were breeding maned wolves and the future of the zoo population seemed secure.

A Disappearing Act?

Recently, however, things have taken a turn for the worse. According to Dietz, much of the maned wolf's habitat in Brazil has been eliminated by continued agricultural development. And while no reliable population estimates are available, Dietz fears that the number of maned wolves has declined as their habitat has shrunk. Further, maned wolves in U.S. zoos have nearly stopped breeding and are beset with medical problems that threaten the entire U.S. population.

Until Dietz's work, the maned wolf had been among South America's least-known large mammals. Dietz, a former research associate at the National Zoo and now a zoology professor at the University of Maryland, studied maned wolves at the Zoo's Conservation and Research Center (CRC) in Front Royal, Virginia, and in Brazil's Serra da Canastra National Park. Patience, determination, and radio collars allowed Dietz to uncover some of the secrets of this elusive, shy, and nervous member of the canid family.

The largest of South America's canids (others include crab-eating foxes and bush dogs), the maned wolf is not a true wolf. Neither is it a true fox, although it is often described as looking like a fox on stilts. Scientists place maned wolves in a genus all their own, *Chrysocyon*, and their evolutionary origins remain obscure.

The maned wolf possesses a striking reddish-gold coat, highlighted by a black mane and lower legs, and a tail and throat tipped in white. It measures about four feet in length and weighs about 50 pounds—the size of a smallish German shepherd. Standing two-and-a-half feet tall, the maned wolf's long legs support a surprisingly thin body, accentuated by its long, tapering, foxlike snout.

Dietz explains the maned wolf's long legs by comparing the maned wolf to the bush dog. The short, stocky bush dog, which inhabits forests and forest edges from Panama to Brazil, moves through grasses by walking between individual plants at ground level. Maned wolves prefer grassland and scrub forest, known as "cerrado" in Brazil, which features short trees and bushes with grass underneath. In contrast to the bush dog, the maned wolf uses its long legs to stand above the tall grasses when traveling with a seemingly tireless gait.

Within grassland and cerrado habitats, maned wolves range from east-central Brazil south into Argentina and west to Peru. They have disappeared from some parts of their historical range, which included southern Argentina and northern Uruguay. On the other hand, they have expanded their range into the "Zona de Mata," a narrow strip of

former tropical forest, stretching from Brazil's Atlantic coast to Paraguay, that has been largely cleared for agriculture.

At Serra da Canastra, Dietz learned that the territory size of a maned wolf pair averaged 12 square miles. Using that figure, he estimated that the maned wolf population numbered about 185,000 animals in 1980. While admitting this was more an educated guess than a hard figure, Dietz suggested that the maned wolf might not have been as endangered as some people then feared. This finding, together with the wolf's ability to extend its range into agricultural areas, encouraged conservationists 10 years ago.

Maned wolves can live quite nicely, Dietz says, in the margins between traditional South American farms. Often left unplanted, such margins provide habitat for wolves and their prey. In addition, Brazilian ranches, some of whose owners protect wildlife on their land, contain plenty of maned wolf grassland habitat. But recently the nature of Brazilian agriculture has changed. More and more, Brazil's farms and ranches are being converted from conventional mixed crops and pastures to soybean monocultures. Soybean fields tend to be planted "wall to wall," Dietz says, with little or no marginal land for maned wolves between them. In some areas, too, the cerrado scrub forests are being replaced by plantations of imported eucalyptus trees, also unsuitable for maned wolves.

Such has been the case in the area surrounding Emas National Park in south-central Brazil. Emas now supports a good population of

maned wolves, but the surrounding land, once traditional farms and cerrado, is now covered with soybeans. With only 400 square miles, Dietz worries that Emas alone lacks sufficient area to support enough maned wolves to ensure the population's continued genetic viability and, hence, its survival.

"The handwriting is on the wall," Dietz warns. "As the areas around Brazil's national parks become developed and broken up, maned wolf populations will be reduced and isolated, and inbreeding will increase. The maned wolf is a fragile species—it is not as flexible or adaptable as some others."

The maned wolf's fragility has also become apparent in the zoo population. In the early 1980s, 130 maned wolves lived in 28 zoos in the U.S., Brazil, and Europe; nearly half of these were zoo-born. The National Zoo alone maintained 18 maned wolves, the largest single collection. The Zoo's five breeding pairs produced 38 pups between 1976 and 1984, all at CRC.

Between 1984 and early this year, however, no pups were born at CRC and only 10 animals remained in the Zoo's collection. Further, few maned wolves have been born in any U.S. zoo since 1986, says Melissa



Maned wolf (*Chrysocyon brachyurus*) at the Zoo. (Photo by Milton H. Tierney, Jr.)

Rodden, a biotechnician at CRC and species coordinator for maned wolves in U.S. zoos.

One problem is that high infant mortality has always kept the zoo population from growing very quickly. Nearly half of zoo-born pups die before reaching adulthood, Rodden says, most a day or two after birth. Many of these deaths may be caused, at least in part, by the pups' parents.

"We hear the pups one day and they are gone the next," Rodden says. It is unclear whether the pups die and are eaten by the parents or whether one of the parents kills and eats them. The National Zoo and some other breeding facilities are now video-monitoring young pups to investigate this issue; some are also removing the pups for hand-rearing.

Another problem is the timing of maned wolf births. In North America, pups are born in December or January, the coldest months of the year. Unable to regulate their body temperature very well until they are a few weeks old, the pups can become chilled and die when moved around their zoo enclosure by a nervous mother.

To compound these problems, some zoos that once actively bred maned wolves have stopped doing so. The Oklahoma City Zoo, for example, had an off-site breeding area where maned wolves could mate and raise pups away from noise and crowds. Between 1980 and 1986, 27 pups were born there, says Jack Grisham, the zoo's general curator. In 1986, however, that zoo lost its off-site breeding area and had to reduce the size of its maned wolf population, Grisham says. The Oklahoma zoo would like to continue breeding maned wolves but, like NHP, is having trouble. Its few remaining maned wolves are either too old or too young and inexperienced to breed.

Various medical conditions also afflict maned wolves. Chief among them is cystinuria. Cystinuria is a metabolic disorder, characterized by high levels of the amino acid cystine in urine, which can cause kidney stones in maned wolves and other species including domestic dogs and people. In female maned wolves, the stones can cause urinary tract infections and in males they can obstruct the urethra. In the last 15 years, at least three male maned wolves have died as a result.

Tests in the early 1980s showed that 80 percent of both wild and zoo maned wolves had high levels of cystine in their urine, says Kenneth Bovee, professor of veterinary medicine at the University of Pennsylvania and an advisor to the National Zoo. Maned wolves with cystinuria do not always develop kidney stones, but most do, and therefore suffer from chronic renal infections and related problems. Cystinuria's cause is unclear although some suspect it is due to an inherited inability to process cystine. For now, the National Zoo is giving some of its maned wolves a drug, Thiola, which is used to control cystine levels in people, says Mitchell Bush, the Zoo's chief veterinarian.

To help solve the zoo problems, maned wolves became part of the American Association of Zoological Parks and Aquariums' Species Survival Plan in 1985. Under the plan, zoos are working together to increase the growth of the zoo population and are studying maned wolf management, diet, and physiology.

In one project, NHP and other zoos are trying to determine how best to house pairs of maned wolves to stimulate breeding and increase



Zoo biologists are struggling to save zoo populations of maned wolves. (Photo by Milton H. Tierney, Jr.)

pup survival. "We want to know what housing changes might be necessary for successful pair interactions," says Devra Kleiman, the Zoo's assistant director for research. Dietz's research in Brazil and at CRC revealed that maned wolves form monogamous pairs to defend a joint territory, but the male and female spend very little time together except to breed. (Whether males in the wild assist with pup care is not known.) Recreating such a social environment for pairs in zoos is a challenge and may or may not increase breeding success.

Also important, Kleiman says, is to learn whether feeding maned wolves a more natural

diet will aid their health and breeding. In the wild, maned wolves subsist largely on a host of small- to medium-sized prey such as birds, mice, rabbits, and armadillos. But surprisingly, Dietz found maned wolves to have a more vegetarian diet than any other canid. "Maned wolves are not fussy eaters," he says. During the rainy season or where animal prey is scarce, fruits, nuts, and other plant material make up half of the maned wolves' diet. Indeed, one staple item is a fruit, *Solanum lycocarpum*, known locally as "fruta do lobo" or fruit of the wolf. Most zoos feed maned wolves a standard canine diet but, says Kleiman, "Maybe there are some chemicals in the food they eat in the wild that trigger the hormonal responses needed for mating and reproduction."

Duane Ullrey, an animal nutritionist at Michigan State University, is also analyzing *Solanum lycocarpum* to see if it might help maned wolves avoid kidney stones. To date, however, Ullrey hasn't found anything in the fruit that might prevent cystinuria.

Zoo veterinarians are also collecting blood and urine samples from all 61 maned wolves now in U.S. zoos for various types of analyses. Ulysses Seal, working at the Minnesota Zoo, is trying to learn whether females are ovulating properly, and David Wildt, the National Zoo's chief reproductive physiologist, is assessing the reproductive capabilities of both males and females. Bovee continues to test for the incidence of cystinuria.

Meanwhile, scientists are seeking to apply artificial reproductive technologies to maned wolves. Unfortunately, the successful techniques developed at the National Zoo for artificially breeding tigers and black-footed ferrets are not likely to work for maned wolves, Wildt says. It is difficult to collect semen from males, he explains, and because the ovaries of females are covered with fatty tissue, they cannot be examined or their eggs extracted without surgery.

Still, there is reason to be hopeful about the maned wolf's future—or at least its future in zoos. Some 265 maned wolves live in European and other non-U.S. zoos, where 70 were born in 1988 alone. Additionally, five litters were born in U.S. zoos this year, from which six individuals survive. And, closer to home, the National Zoo last year received the first wild-caught maned wolves sent to the U.S. from Brazil in 15 years. Zoo keepers are hoping for pups this winter. ♣

Jeffrey P. Cohn is a freelance writer specializing in natural history and conservation subjects.

Text and Photos by Marty Condon

When I was nine years old and was asked “What do you want to do when you grow up?” I had an answer ready. I wanted to live in the woods and study “nature.” I had already picked out a spot in the spruce forest of northern Ontario where I would live in a log cabin with lots of books and endless opportunities to watch animals. In my mind, nature meant animals, not plants. Animals fascinate me, and always have, but plants...? Quite frankly, plants never interested me—until I embarked on a modified version of my childhood dream.

For four years, I lived in a rainforest in a national park in northern Venezuela. Guatopo National Park is a tropical paradise complete with mountains, mist, macaws, and monkeys. I lived in a little house in the park by a beautiful stream called Agua Blanca that once drove a

Opposite page: The Venezuelan rainforest.

SEX CHANGE IN THE TROPICS

-OR-

WHY FEMALES HAVE TO BE BIG TO HANG LOOSE



water wheel supplying power for a sugarcane mill. Forest stands where 40 years ago there were fields of sugarcane, and tracks of jaguar and tapir are now more common along trails than tracks of people. In that forest, and in the primary forest four miles away, I got to know some vines called rainforest cucumbers (*Gurania* and *Psiguria*), and discovered that plants can actually be interesting. I found out that rainforest cucumbers change sex and I decided to find out why. In the process, I found myself in the middle of an intricate web of interactions involving the sex-changing rainforest cucumbers and an amazing array of animals.

Sex change in humans is one of those events that can still make headlines for the *National Inquirer*, but for some plants sex change is a normal part of life. Most of us vertebrates have a single set of gonads (ovaries or testes) that we keep for life. That means that each individual produces only one kind of gamete—eggs or sperm—and is either male or female, not both. Not so for plants: Flowers are ephemeral structures that bear the equivalent of multiple disposable gonads. Imagine having multiple sets of testes and ovaries that function either synchronously or asynchronously for just a short time—a few hours, a day, a month—and then fall off. During a given mating season, sexually mature individuals of most species of flowering plants act as both males and females—but not necessarily at the same time or to the same degree. That is, some plants act as males in the morning or early in the mating season, and then act as females later in the day or in the season.

Everything I had read about rainforest cucumbers said that they were dioecious, which means that individual plants are either male or female for their whole lives. That alone made them fairly unusual in the plant world (although somehow more “normal” from our animal point of view). Other things about them made them seem especially weird: Some authors reported that in natural populations of rainforest cucumbers there were many more male plants than female plants. Male-biased sex ratios are very rare in nature. In fact, mathematical models say that male-biased sex ratios should never evolve. Why would there be more male plants than female plants in populations of rainforest cucumbers?

An answer occurred to me while I was walking down a trail in the forest in Guatopo National Park. I was counting flowers of rainforest cucumbers, not because I was interested in plants, but because I was studying hummingbirds and wanted to assess the amount of food there was in the area. While counting I happened to notice a pattern: Most of the female vines were huge, while the male vines, in comparison, were much smaller. Then I saw something that put rainforest cucumber sex in a new light: I saw a vine changing sex. This vine was just beginning to produce female flower buds at the tip of a long, pendulous branch. Several feet back along that branch, almost hidden in the supporting vegetation, were some flowers that were beginning to die back. Those two observations (females were big and plants can change sex) suggested an hypothesis that I thought might explain why

there were more male rainforest cucumber plants than female plants. My hypothesis was that size determined the sex of rainforest cucumber plants. The sex ratio would then just be a consequence of the number of plants of different sizes in a population. Since there are usually more small plants than large plants in a population, a male-biased sex ratio would be the result of such size-related sex change.

I measured a lot of vines and found out that my hunch was right: Male vines are small and female vines are large. Still, I was puzzled. Why did the vines wait so long to be female? If there were many more males in a population than females, and if you could choose to be either sex, which sex would you be? Female, of course. The rarer sex tends to have a reproductive advantage. So, if size controls sex, and females are rare, why don't these vines turn female at a smaller size? Why is there an association between size and sex?

I thought the association between size and sex might be due to the different costs of being male versus female. Perhaps vines below a certain size simply could not function as females. Females not only invest more energy in each gamete than males (egg cells are bigger than sperm cells), but females also invest more energy in the production of offspring. Maybe vines below a certain size had insufficient reserves to sustain fruit and seed set.

To test that idea, I cut a large vine into short sections, each about a yard long, and planted the sections in a garden. One of those sections eventually flowered, first as a male and then as a female. When it was female, it produced plenty of fruit and fertile seeds—as many as a vine many times its length would have produced—and didn't die after producing such a crop. Yet, that vine weighed less than the smallest male vine I have ever measured. Clearly, then, short vines have sufficient energy to sustain fruit set. So, I was back at the beginning: Why is there an association between size and sex? Why do these vines wait so long to be female?

I was still convinced that the answer would lie in the high relative cost of being female. But if that cost wasn't in the amount of energy invested in seeds and fruit



Ants feeding on the nectar of a rainforest cucumber flower.

versus pollen, where was it?

In populations in which males are more common than females, the average female will parent more offspring than the average male. Vines that turn female early (at a smaller size) should therefore have a reproductive advantage over vines that remain male—unless there is some overriding disadvantage to being female when small. For rainforest cucumbers, I was sure that there was a hidden cost of femaleness, and that it was related to size.

Besides the obvious differences in reproductive traits (female flowers, fruit, and seeds versus male flowers and pollen), how do the male and female phases of a rainforest cucumber plant differ? The two sexes have very different behaviors. When these vines are in their male phase, they act like normal vines: They climb. Climbing is what vines do for a living. When these vines turn female, however, they stop climbing. Vines that are entering the female phase stop producing tendrils and normal leaves, and actively turn the tips of their branches down toward the ground. The branches (which would otherwise be climbing over the tops of the trees) just take a dive and hang loose from the supporting vegetation. These strange diving branches may drop several feet before they produce their first female flowers. So male vines climb; female vines dangle. This sex-related difference in behavior was just the kind of cost I was trying to find, because cost depended upon a vine's size.

I decided that hanging loose, not climbing, was probably a very expensive proposition for a small vine. My hypothesis is that hanging loose represents the hidden cost of femaleness and so determines the size at which



Spider repelling other insects on a cucumber flower.

vines change sex. How does the cost of not climbing change with vine size? To figure that out, I thought about why vines climb.

What is climbing? To climb is to ascend, to move upward. For a plant, why is moving upward advantageous? Access to light, of course! Light is the energy plants use in order to "eat." There is very little light in the understory, but lots of it at the top of the canopy of the forest. So, the higher a plant goes, the more light it can capture to fuel its consumption of carbon dioxide. Actually, not all plants are able to increase their rates of photosynthesis with increased light intensity, but rainforest cucumber vines can, as Dr. Gustavo Montes, a plant physiologist at the Universidad Central de Venezuela, and I found when we measured photosynthetic rate under differing light intensities. So, the higher the vines climb, the more intense the light, and the faster the photosynthesis and consequent growth.

My hypothesis predicts that the size at which these vines change sex should correspond to the size at which the cost of not climbing is minimal. The point at which a vine can afford to stop climbing is the point at which it would normally attain a stable position in the canopy. At that point, the vine's struggle to climb to the top of the forest has finally paid off, and it has lots of leaves basking in full sunlight. Then, and only then, can it afford to take time off from its business of climbing, turn female, and hang loose.

How does a vine "know" that it has reached that point? At first I thought that high light intensity would be the best indicator of canopy position, and that vines should change sex in response to light. But then I realized that light is actually a pretty fickle indicator. Light intensity in the middle of a clearing at ground level can be as high as light intensity in the

canopy. If small vines in a clearing changed sex in response to high canopy-like light intensity, those vines would soon find themselves in the understory. Many plants grow very quickly in clearings in the tropics, and could easily grow over and shade a vine that had stopped climbing for a month or more to become female. In fact, when I tallied my observations, I found that small vines in clearings never produce female flowers, even though those vines are exposed to as much light as they would experience at the top of the canopy.

So vines do not use light alone as an indicator of canopy position. They need a more reliable cue. How about size? (By size, I mean diameter of the stem; my previous experiments had already shown that length does not affect a vine's ability to be female.) Vines that make it to the canopy are never skinny: The average diameter of canopy vines is much greater than the average diameter of low vines. So, I predicted that the minimum diameter of female vines would correspond to the average diameter of vines that have attained canopy position. To test this prediction, I measured the diameters of vines whose branches I could see ("low vines") and the diameters of vines that had disappeared into the canopy ("canopy vines"). Much to my delight, the minimum diameter of female vines corresponds to the average diameter of vines with canopy status.

Still, I was puzzled. If the association between size and sex—which often results in a highly male-biased sex ratio—evolved because hanging loose is too expensive for small vines, then why hang loose? And why do females, not males, hang loose? How did such bizarre behavior evolve? Might branch behavior (climbing versus hanging) influence the behavior of any animals that affect rainforest cucumbers' ability to survive and reproduce?

Up until now, I have been talking about plants as if they might actually be interesting organisms all by themselves. All by themselves, however, many species of plants would soon become extinct. For many flowering plants, courtship, mating, parenthood,



Passion flower, part of the interconnected web of the rainforest.

and fledging are community affairs that include not just mates, parents, and offspring, but a whole array of other species, which, in turn, depend upon their interactions with plants. In the case of rainforest cucumbers, that community is extensive. Courtship and mating involves the attraction of beautiful passion vine butterflies and hummingbirds; parenthood involves production of fruit that attracts and is eaten by huge harem-forming bats that disperse seeds, the fledglings of the vine. Parenthood also involves protecting those seeds from predators: finches, squirrels, mice, monkeys, pickleworms, coreid bugs, and at least one species of fruit fly in the genus *Blepharoneura*, a relative of medflies. Does branch behavior affect a vine's attractiveness to pollinators, bats, or predators? I predicted that branch behavior might affect bats or predators, but not pollinators. Many plants that attract bats produce fruit on long dangling stems, so I expected that branch position might affect bats. In contrast, pollinators, which must visit both male and female flowers to be effective, should not discriminate between climbing versus hanging branches.

To test those predictions, I spent hundreds of hours watching flowers and checking fruit. I noted whether branches were

touching vegetation or hanging loose, and whether or not pollinators, dispersers, or predators visited the branches. As I predicted, hummingbirds and butterflies visited flowers on branches that hung free of vegetation as well as those that didn't. Contrary to my predictions, bats take fruit from branches touching the vegetation almost as frequently as from branches dangling below the vegetation.

What about predators? Is hanging loose an effective way to escape predators? Branches that hang loose effectively escaped rodents, but not fruit flies. Fruit flies attacked a much higher proportion of free-hanging branches than vegetation-bound branches.

Is the advantage of escaping rodents canceled out by the disadvantage of attracting flies? I think not. Flies generally kill fewer than half the seeds in a fruit, and do not disrupt a fruit's development. Fruit attacked by flies remains attached to the vine, matures normally, and is readily eaten by the bats that swallow and disperse seeds. In contrast, rodents generally kill all the seeds of the fruit they attack, and often destroy immature fruit.

Hanging loose is one way to escape the rat race. ♣

Marty Condon is a FONZ supported postdoctoral fellow, developing butterfly exhibits at the Zoo.



Mouse feeding on rainforest cucumber fruit.

Lectures at the National Zoo

Adventuress Carol Beckwith's slide-illustrated lecture on *High Adventure in Far-Off Africa* will be held Wednesday, November 7, at 8 p.m. in the Baird Auditorium of the Natural History Building. A reception, courtesy of Harry N. Abrams, Inc., and the Smithsonian Shops follows. The RAP-sponsored event will have copies of Beckwith's new book, *African Ark*, for sale. For more information call RAP at 202-357-3030.

Come hear Paul Butler speak on *Environmental Education in the Caribbean* on Wednesday, November 14. The free lecture is co-sponsored by RARE Center for Tropical Bird Conservation and NZP. For reservations and more information call 202-673-4801.

On Tuesday, November 27, in celebration of its 25th anniversary, the Resident Associate Program will cosponsor a special lecture entitled *Joys of Biology* by Zoo Director Michael H. Robinson. A reception begins at 7 p.m. followed by the lecture at 7:30 p.m. in the Education Building. Tickets are free, but required. Contact RAP at 202-357-3030 for more information.

Holiday Zoobilee

Join the festivities of Holiday Zoobilee, the second annual winter celebration at the National Zoo. Beginning Saturday, December 1, FONZ members will once again have the chance to decorate evergreens with lights and ornaments along Olmsted Walk, the Zoo's main pathway. Prizes will be awarded for the tree best decorated using recycled and natural ornaments. On the evening of Friday, December 7, watch as the trees are magically lighted at a ceremo-

ny; then, listen to the holiday sounds of The Levine Chamber Orchestra.

Throughout the days of celebration, the Zoo will be bright with music and lights as guests and carolers stroll through the wintry grounds. Hours will be extended for guests to peruse the Zoo's Bookstore and Gift Shops for unusual cards and gifts. The Reindeer Room, a special gift shop where children select special gifts on their own, will reopen this year with all merchandise priced at or below \$10. Zoobilee participants of all ages can challenge themselves with the "Discover the Zoo" scavenger hunt.

FONZ members are also invited to an exclusive production of *The Velveteen Rabbit* on Saturday, December 8. In place of an admission fee, members will be asked to bring a new, unwrapped toy. The toys will be given the following day to area homeless children at a performance just for them. Also on Saturday evening, the D.C. Community Orchestra will entertain listeners with "Peter and the Wolf."

The music continues on Sunday, December 9, with the holiday jazz program "Tea at the National Zoo."

And, Holiday Zoobilee doesn't end with the holidays! You'll be able to help the Zoo in the coming year by bringing your old Christmas tree to the Zoo to be made into mulch for use on Zoo grounds.

Special this year, in conjunction with events at the Zoo, will be Zoobilee events including a scavenger hunt, face-painting, puppet shows, and many other activities at Potomac Mills Mall, a project of Western Development Corporation, which is helping to support Zoobilee.

For more information call 202-332-WILD.

New at the Zoo

After a 45-year absence, red wolves have returned to the Zoo. A pair the Zoo hopes to breed is now on exhibit in the wolf yard along the Beaver Valley Trail. If all goes well, their offspring will become part of the U.S. Fish and Wildlife Service's recovery program for this endangered species. Look for the upcoming article on red wolves in the next issue of *ZooGoer*.

Beach Cleanup

As part of National Beach Cleanup Week, FONZ volunteers picked up more than 1,000 pounds of trash from the Mason Neck Wildlife Refuge, an important nesting area for endangered bald eagles on the Potomac River.

FONZ provided lunch and transportation for the 23 volunteer garbage collectors, who also separated the trash for recycling. The Alliance for the Chesapeake Bay donated trash bags and "Pick up the Beach" T-shirts, and BFI Waste Management provided a dumpster and hauled the trash away.

The volunteers spent three hours at the beach, collecting nearly twice as much debris as the national average for all beach cleanups last year, according to FONZ program coordinator Shawn Mallan. The highlight of the day, he says, was a glimpse of a majestic bald eagle soaring over the newly clean shoreline.

FONZ News

At the October 19 Annual Meeting of the Friends of the National Zoo, Thomas H. Goss, Suzanne Mink, and Lee Sutherland were elected to first terms on the FONZ Board of Directors. Richard D. Buckner and William D.

Hawkins III, were reelected to second and third terms, respectively. George A. Didden, III, was also elected to his fourth term as President of the Board of Directors. Other officers are: Richard D. Buckner, First Vice President; Ine N. Noe, Second Vice President; William D. Hawkins III, Treasurer; and Elizabeth B. Frazier, Secretary. FONZ wishes to thank departing Board Members Anne Hamilton and James F. Rogers for their nine years of service.

The Annual Meeting also provided the setting for the formal dedication of *Volunteers*, the exquisite tree sculpture by artist Steven Weitzman, commissioned by FONZ and the Zoo to honor the enormous contributions that volunteers have made to the Zoo in the last 32 years. At the dedication, a proclamation from President George Bush was read that declared FONZ volunteers to be examples of "points of light." *Volunteers* can be viewed at present on the Zoo's Great Meadow, opposite the Reptile House.

Finally, the hundreds of FONZ members attending the Annual Meeting were treated to a special Zoo-by-Night Tour, a rare opportunity to explore the nocturnal life of the Zoo.

Water Lily Pond

Late last spring on Olmsted Walk near Panda Plaza, staff members of the Landscaping Unit created a pond that showcases the beauty of water plants and highlights several species of water lilies. It has become an oasis of peace and tranquility in one of the busiest areas of the Zoo. Lavender blossoms of water hyacinth cluster by the bank, and rocks tumble down a hill into the still water. Delicate fronds of the umbrella palm

beckon passers-by to pause for a closer look. The croaks of frogs and the rustle of the breeze through ornamental grasses harmonize with bird songs and noises from nearby animals.

Three kinds of water lilies provided the focal point of the pond: the common, local variety of water lily with modest-sized pads; and two more unusual species, both with enormous round pads. The first, *Eurayle ferox*, native to Bangladesh, India, and China, is distinguished by its rough, textured leaves. The second, *Victoriana*, is a hybrid of two South American water lilies, *Victoriana cruziana* and *Victoriana amazonica*. These two species of the water lily grow in rivers from Guyana to Argentina. In 1961, Longwood Gardens in Kennett Square, Pennsylvania, successfully crossbred the two species to produce a hybrid that is hardier in northern climates and that flowers more prolifically than its wild relatives. The water lily has become a favorite at botanical gardens in Europe and North America both for its gigantic size and its showy flowers.

Victoriana bears a striking

resemblance to a huge, Art-Deco quiche dish: Its large rough leaves are encircled by an upturned, rose-hued rim. Its leaves are truly regal in size. The leaves in the Zoo's pond were almost four feet across, but they can grow to 6-1/2 feet. One of the largest leaves on record measured 7-1/2 feet across and grew here in Washington at the Bartholdi Basin Garden (near the U.S. Botanic Garden on Capitol Hill) in 1891.

The floating leaves of the *Victoriana* conceal an incredible strength: They can easily bear the weight of an average-sized person. A look at the underside reveals the secret of their strength—the leaf is supported by a network of strong, deep veins. The entire bottom is armed with prickles, which are believed to help protect the plant from being nibbled at by fish. Tiny holes, which can be seen with a magnifying glass, perforate the entire leaf surface. The holes allow rainwater to drain away and also give the plant added protection against fungi and algae.

When European botanists first became acquainted with the *Victoriana* water lily in the early 1800s, a number of fruitless attempts were made to

grow the plant from seeds. In 1846, the Kew Royal Botanic Garden in London successfully germinated seeds that had been stored in a jar of wet clay, but the plants did not mature. Finally, in 1849, seeds sent from South America to the Duke of Devonshire's gardens at Chatsworth in Derbyshire, England, germinated, matured, and produced a flower. The superintendent of the Chatsworth gardens was Sir Joseph Paxton, a noted landscape gardener. He also gained renown as a designer of hothouses. At Chatsworth, having closely studied the *Victoriana* water lily, he built a conservatory and a water lily house and derived the design for these structures from the intricate, veined pattern he observed on the underside of the *Victoriana* leaf. These conservatories, in turn, provided Paxton with the basis for the structural design of the Crystal Palace, built in London in 1851 for the Great Exhibition. Thus, the origin for the design of the Crystal Palace, a triumph of 19th-century architecture and technology, is rooted in the leaf of a South American water lily.

The water lily that helped fuel Paxton's career was named *Victoriana*, in honor of the British monarch, Queen Victoria. Appropriately enough, the first flower that bloomed at Chatsworth was presented to the Queen.

Planting and caring for the Zoo's water lily pond has been one of Zoo gardener Bill Burke's summer projects, and he was frequently seen working in the area. Burke explained that the seedlings for the exotic varieties of water lilies were a gift from Longwood Gardens, where they were started indoors. The tiny plants arrived at the Zoo and were set outside in mid-July, when Washington temperatures rarely dip below 78 degrees.

Burke planted them in a 6-x-6-foot planter filled with organic compost and soil. The planter is standing on concrete blocks stacked on the bottom of the pond. The blocks are gradually removed as the water lily grows. Burke says that warm, summer temperatures and long, sunny days, combined with the gradual lowering of the planter (which keeps the lily pads at just the right level on the water) are the keys to success with this species.

The *Victoriana* hybrid delighted a number of Zoo cognoscenti when, in mid-September, it produced several flowers. Its ivory flower opens in the evening and closes by midmorning of the next day. It reopens once again that evening and the color deepens to a rose-pink. The bloom exudes a sweet, pineapple-like fragrance. In its native South American habitat, *Victoriana amazonica* is pollinated by a beetle, but in these northern climes, the process of pollination requires a bit of human assistance. On the first night that the water lily blossomed, Burke collected grains of pollen by using a horsehair brush. The next night he dusted the pollen back onto the flower. After the flower finished blooming, Burke covered the spent blossom with cheesecloth and allowed it to sink beneath the surface of the water. Each flower produces three or four seeds, which are caught as they fall into the cheesecloth bag. After the seeds are washed, they are stored in distilled water and kept in a refrigerator until February or March, when they are brought out to sprout. Then, Burke will begin the process all over again for next year's display on the pond.

—Margie Gibson
NZP Staff Writer



Water lily pond at the Zoo this past summer. (Photo by Jesse Cohen/NZP Graphics.)

Rediscovering a Living Fossil

The tuatara, a large iguana-like reptile existing only in New Zealand, was recently found to be not one but two distinct species, according to a new study published in *Nature*. This long-standing error in taxonomy, or species classification, inadvertently may have pushed one of the species (*Sphenodon guntheri*) to the brink of extinction.

Biologist C.H. Daugherty and colleagues at the Victoria University of Wellington in New Zealand called for the new classification based on genetic and physical differences they found between *Sphenodon punctatus* and *Sphenodon guntheri*. Their findings support a 19th-century taxonomic listing that recognized two living species of tuatara, a listing that was virtually ignored for more than a century.

Tuatara are the only survivors of a reptile group that

flourished 200 million years ago, before the first dinosaurs. Introduced rats, rabbits, goats, and pigs have devastated the tuatara's habitat and food supply; only 60,000 of the reptiles remain, confined to 30 tiny coastal islands.

New Zealand wildlife protection laws dating from 1895 recognize only one tuatara species, *punctatus*. Because they weren't considered critical to the overall survival of the species, 10 of the 40 known populations of tuatara were allowed to die out. Four more populations are now in imminent danger, Daugherty reports, including the last one of *guntheri*. Fewer than 300 critically endangered reptiles live on a single island.

This rediscovery of *guntheri* underscores the importance of taxonomists, the "lumpers and splitters," who classify living things according to their evolutionary relationships. Taxonomic status is a critical

element in managing endangered species; a distinct species is afforded greater protection than either a subspecies or a geographically separate population. A false sense of security arising from the failure to recognize unique organisms allows neglected species to perish unheralded and robs us of biodiversity that we never knew existed.

—Mary K. Miller

Public or Private Land?

While small in number they are the center of a large controversy. An estimated 50 Florida panthers are the focus of a conflict of interest between conservationists and private landowners in Florida. In an effort to prevent the extinction of the Florida state mammal, conservationists, backed by public opinion, seek to preserve private lands for wildlife. Yet, private landowners in "strategically located areas" in southern Florida oppose this proposal in favor of other land-use options. Because the land holds value for both groups, a conflict has arisen with the Florida panther at center stage.

David S. Maehr of the Florida Game and Fresh Water Fish Commission proposes preserving a large tract of private land for the Florida panther. He believes this is necessary because the wide-ranging panther does not confine its movement to federal and state lands. The panther roams through biotic systems, both public and private, which provide a thriving habitat not only for the panther but for other threatened plants and animals as well. Further, Maehr found that

Florida panthers living on private lands proved to be "in better physical condition and more productive than individuals on public lands." Private lands with fertile soil, both natural and cultivated, are conducive to agriculture and other development.

Conservationists fear the panther's southern Florida habitat of 2,176,000 acres will diminish by the 45 percent that is now private land, shrinking the current population of 30 to 50 adults to 9 to 22—a population too small to exist for long in the wild.

Yet a solution that will protect the panther and appease the private landowners is not simple. Provisions of the U.S. Endangered Species Act may help prevent the loss of the panther's habitat, but this alternative is considered costly for federal agencies. So conservationists look for state intervention and a compromise. But in the meantime the panther's biotically diverse environment decreases as the development continues, pushing the panther closer to extinction.

—Natalie J. Jordet



The tuatara, a large iguana-like reptile found only in New Zealand. (Photo courtesy of *Nature* magazine.)

Mommy Training for Chimpanzees

While human mothers read Dr. Spock to prepare for their babies' birth, their closest primate relatives have their own kind of prenatal training.

Instruction for wild-born female chimpanzees, nine first-time mothers and one who previously had a stillborn, was part of a recent study by A. C. Hannah and B. Brotman at Vilab, the New York Blood Center base in Liberia. The 10 chimpanzees were among a group of 19 expectant females observed by researchers from



Chimps may need training to be good mothers in zoos. (Photo by H. Amasa Smith/courtesy of the North Carolina Zoological Park.)

Scotland's University of Stirling, in an effort to improve maternal care by captive chimpanzee mothers.

The study tested two approaches with the 10 chimpanzees. In the first, females were offered an unrelated infant to adopt. Six infants were used in this approach, one male and five females, aged one-and-a-half to three years. In the second approach, the females had a "role model"; they were housed with a nursing mother chimpanzee to observe her care of her infant. Of the 10 mothers, two were housed with an adoptive infant, five were housed with an infant and a role model, and three only with a role model.

Training and observation of the mothers, who were between the ages of seven-and-a-half and 20, began in 1985. The mothers-in-training and the nine other female chimpanzees, eight of whom had no maternal experience, were monitored from their arrival at Vilab until after their infants' births. The study published in *Zoo Biology* revealed that those with any previous experience, with one exception, successfully raised their infants. Both experiential methods were found to be equally effective in inducing nurturing behavior. However, the eight mothers with no experience and no training provided improper care, not handling the

infants properly or not permitting them to suckle; their infants had to be removed for human rearing.

In comparing the two groups, the only difference was the mothers' level of experience. The researchers concluded from this that exposing females to either of the situations would increase the chances of appropriate maternal care. The infants raised by their mothers became "behaviorally normal," and their survival rate was higher than infants raised by humans.

Captive chimpanzees are often inadequate mothers because they are separated from their mothers too early to learn maternal behavior.

But the researchers are sure to tell you this method may not work with all captive female chimpanzees. Some female chimpanzees are simply untrainable, as they discovered in one case where three infants had to be removed because of mistreatment. Further, the chimpanzees in the study were all wild-born, reared by their mothers for 6 to 18 months, and held in groups.

At the National Zoo, unlike some captive sites, juvenile primates are housed in social situations, learning maternal behavior directly from their parents, through their own rearing, and observing that of other siblings.

—Natalie J. Jorget

Tracking Ivory

A standard chemical analysis could prove a powerful weapon in the battle against elephant poachers. Using it, scientists have discovered a way to trace ivory back to its source, according to recent articles in *Nature*.

Researchers from the University of Capetown and other South African institutions report that by analyzing individual tusks it is possible to pinpoint the area where an elephant was taken, thereby concentrating efforts to save the endangered species where they're needed most.

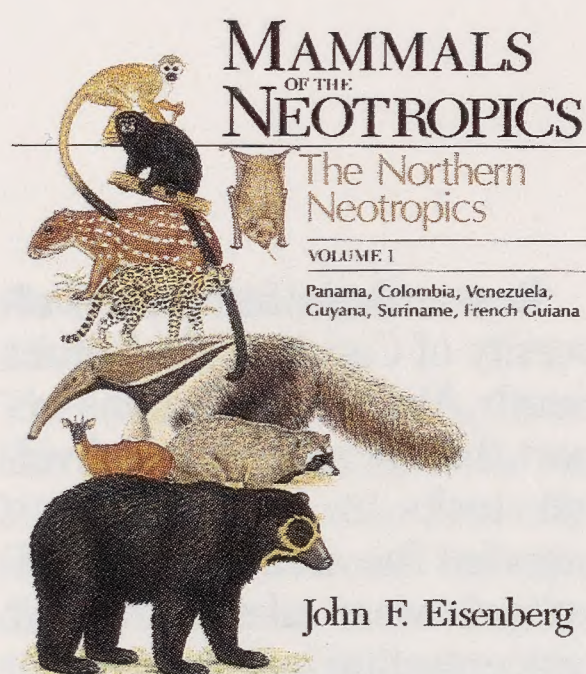
The chemical test used by N.J. van der Merwe and colleagues measures isotopes of common chemical elements like carbon, nitrogen, and strontium. Isotopes are different forms of the same atom, which vary in weight depending on the number of neutrons contained in their nuclei. By comparing the ratios of "heavy" to "light" isotopes of several elements, scientists obtain a "fingerprint" for a particular area. These isotope fingerprints are mirrored in the bones and tusks of the elephants that live there.

Nitrogen was one of the isotopes the scientists used to analyze the origin of elephant ivory. In desert areas with low rainfall, the ratio of heavy to light nitrogen in the environment is higher than in tropical areas.

Carbon molecules also vary, depending on regional vegetation. In woodland savannas, the predominant elephant food is grass, which has a different form of carbon than the foliage elephants rely on in dense tropical forests.

By putting chemical clues together, the scientists have found a clear distinction between several different elephant populations in South Africa. The next step, they report, is to compile a comprehensive index of isotope signatures from all areas where elephants live.

—Mary K. Miller



Cover of *Mammals of the Neotropics*.

Rainforests: A Guide to Research and Tourist Facilities at Selected Tropical Forest Sites in Central and South America.

1990. James L. Castner. Feline Press, Gainesville, FL. 380 pp. paper, \$21.95.

Don't be deceived by the prominent title of this book. It is not about rainforests; the subtitle is important. It is a guide to research and tourist facilities at some rainforest sites in the Neotropics. As such, it fulfills an important but restricted function. If you are a researcher, naturalist, or ecotourist, it is a mine of useful information that will help you to decide where to go.

The book is well-organized and systematic, including country-by-country summaries of available facilities, often complete with photographs. It deals with logistics and costs, and provides very comprehensive coverage of all the practical things you need to know before embarking on a tropical adventure. I checked out the data on Panama, where I lived for nearly 20 years, and found it to be relatively fair and accurate, although Castner's comments on the politics of Panama are, in my opinion, unnecessarily negative.

While *Rainforests* is certainly a good basis for making fur-

ther inquiries, it should not be used as a sole source for making travel preparations. The Panama information, for instance, dates to 1988. In the Neotropics, the situation is highly dynamic, and governments and conditions change, sometimes quite rapidly. So, good as it is, do not rely on this book alone. Things also change at field stations and hotels. Indeed, since this book was written, the Smithsonian Tropical Research Institute facilities have improved by leaps and bounds. A new, modern dormitory is now open on Barro Colorado, as well as a greatly improved and spacious dining facility.

Rainforests contains a very good bibliography of the general literature on the rainforests of the region, useful for background reading. This is an excellent compilation. It also includes a listing of people and organizations that are active in the region. I wish I still were. As a whole, this book is very practical. But do go beyond it and check current conditions before making decisions about venturing into Neotropical rainforests!

—Michael H. Robinson
Director, National Zoo

Neotropical Rainforest Mammals: A Field Guide.

1990. Text by Louise H. Emmons, color plates and illustrations by Francois Feer. The University of Chicago Press, Chicago, IL. 282 pp. paper, \$19.95.

Mammals of the Neotropics: The Northern Neotropics.

Volume 1. 1990. John F. Eisenberg. The University of Chicago Press, Chicago, IL. 260 pp. paper, \$34.95.

The enormous popularity of field guides stems, I believe, as much from the sense of possibilities they create as from

their usefulness in the field. Whether you're planning a weekend trip to the beach or embarking on an exotic safari, you can leaf through the available field guides to see what you might see. You can review the field marks of a rare butterfly or bat—just in case one should fly past your nose—and get to know the names and habits of the common birds and mammals so you can impress fellow-travelers with your biological literacy. You can savor the illustration of a fabulous beast—tiger, bongo, or giant otter—and imagine the magic moment when you meet it face to face in the forest.

Until this year, Neotropical ecotourists interested in mammals had to forego the pleasure as well as the practicality of a field guide. But now, thanks to Louise Emmons, a Research Associate at the Smithsonian's National Museum of Natural History, the field-guide gap is filled. The first-ever broad regional guide to the mammals of Neotropical lowland rainforests, *Neotropical Rainforest Mammals* includes accounts of 206 species and 90 genera of mammals, most of which are illustrated on 29 color and seven black-and-white plates. Each species account features a detailed description of the animal, with traits important for field identification in bold type; vocalizations and other sounds of the species; its natural history; its distribution as well as a range map; its conservation status; and references. Useful appendices include a glossary, an identification key, and line drawings of the tracks of the large mammals. Whether you plan a trek through a Neotropical rainforest or an armchair tour, *Neotropical Rainforest Mammals* is a welcome travel companion.

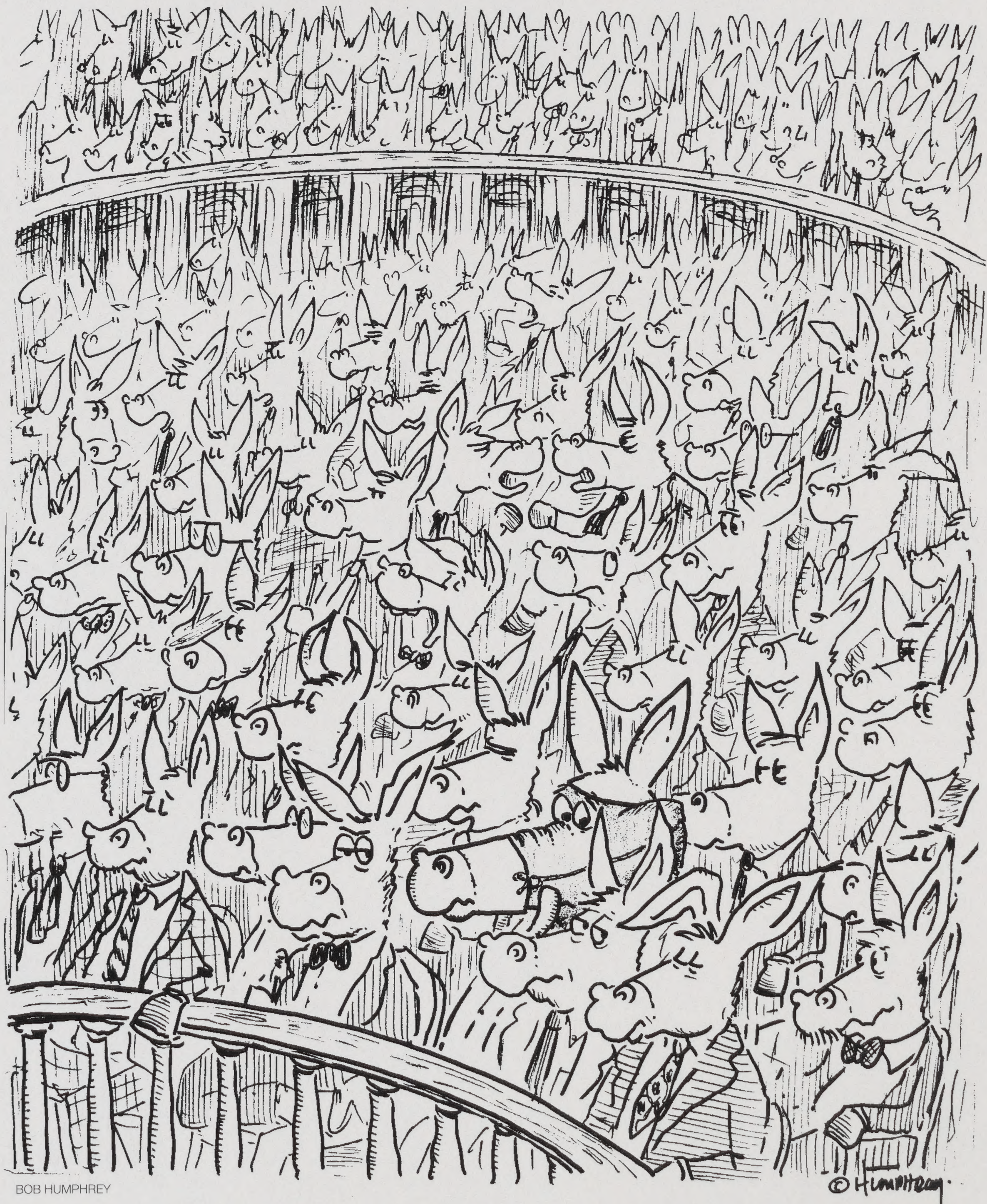
John F. Eisenberg's *Mammals of the Neotropics: The Northern Neotropics* fills an-

other huge gap. The first in a three-volume series, Eisenberg's book provides the only encyclopedic reference for the mammals of the northern Neotropics. Written primarily for specialists and students of mammalogy, this book should also find a wide audience among general readers with an interest in Neotropical mammals or in planning a trip to the Neotropics. Non-specialists will particularly enjoy the excellent summaries of natural history and behavior. These summaries reflect the astonishing breadth of Eisenberg's experience with mammals of all kinds, gained over a lifetime of watching these creatures in their natural habitats and in zoos. (Eisenberg, now Ordway Professor of Ecosystem Conservation at the University of Florida, was formerly the National Zoo's Assistant Director for Animal Programs, and founder of the Zoo's world-renowned Department of Zoological Research.)

The geographic range covered by Eisenberg—Panama, Colombia, Venezuela, Guyana, Suriname, and French Guiana—is smaller than that covered by Emmons. But the range of species included, nearly 450, is broader; it encompasses groups such as whales and seals and sea lions not found in rainforests, and species found above about 3,000 feet. Line drawings and 21 plates, most in color, supplement the text. *Mammals of the Neotropics* will make a wonderful addition to anyone's natural history library—and should be read along with *Neotropical Rainforest Mammals* before any trip to the Neotropics.

—Susan Lumpkin

These and other books on rainforests are available in the Zoo Bookstore in the Education Building at the National Zoo.



BOB HUMPHREY

CONGRESS

A professor of anthropology at George Washington University, Bob Humphrey recently completed a book of "Last Elephant" cartoons. The 72-page book costs \$4.95 (\$4.46 for FONZ members) and is now available at the Zoo Bookstore, National Zoological Park, Washington, D.C., 20008. (If ordering through the mail, please include \$1.65 postage and handling for the first book and \$0.25 for each additional book to the same address. Please do not send cash, stamps, or money orders.)

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